Northern Oil

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Printed and published by Myers' Oil News Ltd., 510 - 5th Street, W., Calgary, Alberta.

FOREWORD

Beyond our settlements, past the farthest thrust of our railroads, deep within the vitals of North America's last frontier, a sleeping giant stirs . . .

Though his face—even now—is scarcely known, his treasure has been fairly measured and his power felt.

The oil industry already knows the nature of his arsenal. Savage climate, vicious terrain and pure physical size are his greatest weapons. Little more than a year ago, the giant's fortress was inviolate. As the foreword to this written, his defences are crumbling before the assaults of technology in action.

One cannot refer to this new struggle without the use of superlatives. Expenditures stagger the imagination, difficulties are magnified monstrously in a land where it is considered an achievement just to stay alive. It is fitting that the stakes, too, are high enough to merit the cost.

Techniques, machines and planning are all vital to success of the great adventure, but each of these is entirely worthless without man. Techniques are no keener than the man who executes them, the most functional machine ever devised is junk without an operator of consumate skill, plans can be transformed into action only in the minds of men.

On the nation's new frontier, the men are proving worthy of their machines and equal to the tasks imposed upon them. To these men, OIL-WEEK respectfully dedicates this book.

They are the pioneers of the Oil Age.

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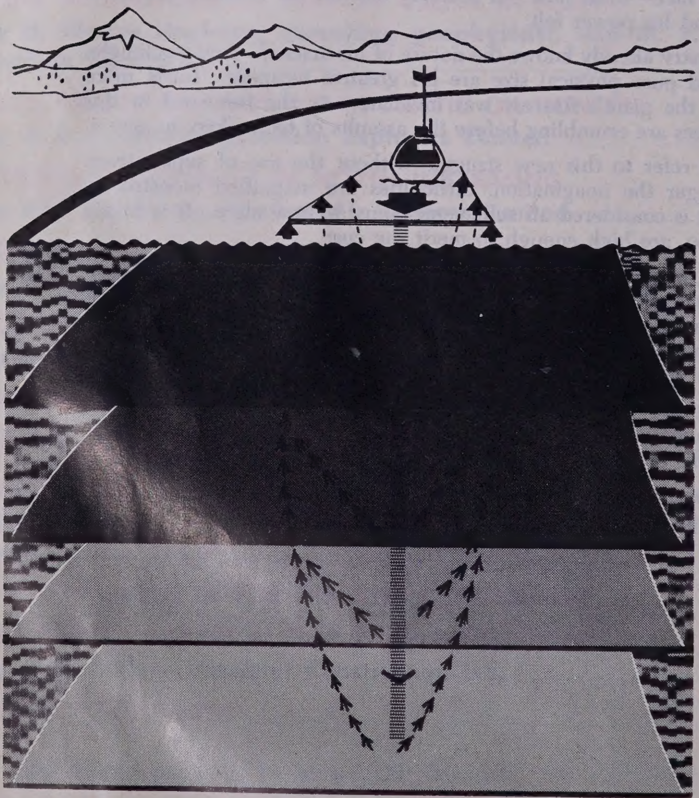

This schematic illustration of StraTometer shows the unit in operation. The reflected signal is received by the array of hydrophones, recorded on magnetic tape, composited and reproduced visually in a continuous profiling seismograph — all in one operation.

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25 TO 100 BILLION BBLS. OIL IN ARCTIC ISLANDS

Five giant structures could yield four billion barrels claims Dome's exploration mngr.

OM OILWEEK, SEPT. 25/59

What is probably the most optimistic report ever published on the oil potential of the Arctic Islands was presented by E. J. Baltrusaitis, exploration manager of Dome Petroleum Ltd. in a paper given to the Canadian Association of Oilwell Drilling Contractors.

The author claimed the islands have more to recommend them as a potential major oil province than had the Alberta basin in the 1920's and concluded that the area will "give us reserves of an amount to make us independent of oil from the Middle East, the Sahara and South America" Following is the paper.

Early this year a land play in the Queen Elizabeth nds in the Canadian Arctic resulted in the filing for nits of 80,000,000 acres. Because Dome acquired a ber of permits I have been asked questions in the wing vein:

What are you doing up there in all that ice and snow?

How are you going to be able to operate?

How are you going to dispose of oil production?

Aren't you 10 years (25 years) too soon in the area?

In order to get some of these answers first hand, ne Petroleum recently arranged an air flight over Islands. Three men from our company and a representative from each of five other companies had the ortunity to study and observe the region from the air the ground. Two loops of flights were made from olute (Figure 1), one generally west of this base and other north and northeast, each loop being approxiely 1,250 miles in length. One stop was made on ld Bay on Prince Patrick Island.

General geology and estimate of oil reserves—Briefly, Arctic Islands are within a deep basin of deposition he north of the Canadian Shield. From the northern ts of the exposed Pre-Cambrian formation, sediments ging from Cambrian to Tertiary in age dip northerly n estimated thickness of 50,000 feet. At least three ortant periods of folding have occurred, providing interesting structural provinces which are now being ied carefully.

The basic requirements for oil accumulation are:

ource beds for oil.

eservoir rocks.

rapping conditions.

These three elements, in proper relationship, result in ields in sedimentary rocks. The present oil play in Arctic Islands seems to have these requirements in y localities.

Let us consider the two Ringnes Islands which are veen Latitudes 78° and 79°. Sediments here may be t 50,000 feet in thickness, consisting of marine and marine rocks, from Cretaceous to Cambrian in age, many visible structural closures on the surface. Four structures of Ellef Ringnes Island cover 40, 122, 144 and 120 square miles respectively. One structure on Amund Ringnes Island covers approximately 250 square miles. If we consider then, that oil fields capable of recovering about 10,000 barrels per acre will be found in these structures, the recoverable oil on the five mentioned would be in the order of 4-1/3 billion barrels.

If one wished to reduce this estimate to 25 percent or even to 10 percent, the amount of oil would still be very substantial and yet not all of the structures on these two islands are included in this estimate. The Ringnes Islands occupy 7,600 square miles of a total islands area of 165,5000 square miles.

There are many closed structures and anticlinal axes visible on the surface of the Queen Elizabeth Islands which, together with the excellent data provided by the Geological Survey of Canada on the stratigraphy of the rocks, give an exploration geologist great hopes for large oil traps. Given a reasonably good coincidence of source and reservoir rocks under these surface structures, this writer believes an estimate of 25 billion barrels of recoverable oil is conservative and a figure of 100 billion not overly optimisitc.

I believe this a reasonable statement that the Arctic Islands, at this time, have much more to recommend them as a potential major oil province than had the Alberta basin in the 1920's or the Mackenzie basin just a few years ago. If new oil seeps were known the above statement could be made in stronger terms.

In addition to the reserves estimated above from surface structural knowledge, one must assume that many stratigraphic traps due to pinch-outs of sediments will be found.

Considering these factors, the Arctic Islands should be a happy hunting ground for oil exploration.

Accessibility and weather—Our flights from August 15 to 21 were made during the period of warm Arctic weather and temperatures ranged from freezing to the low 40's. During that week ships with supplies from Montreal arrived in Resolute and the ice breaker, d'Iberville, which accompanied the ship left to attempt a trip to Eureka, Ellesmere Island, Latitude 80°. Ice conditions in

Lancaster Sound and Barrow Srait generally are broken enough during the summer to permit ships to proceed westward to Resolute annually. With an ice breaker's assistance, ships should be able to service Bathurst, Myam Martin, Melville, West Ellesmere and Axel Heiberg Islands. Some penetration can be expected north of Viscount Melville Sound but generally the area is considered inaccessible to surface ships.

Air lift vehicles feasible?—The recent announcement from England and the United States suggesting successful development of air lift vehicles, could find direct application to the Arctic, particularly where the inter-island areas are frozen and ice is seven feet thick. Certainly other equipment will be developed which will traverse the ice surface with ease and safety and be able to haul the loads and weight of oil field equipment at a cost less than comparable loads in our muskeg and wooded araes. Most of the Islands do not rise above 700 feet in elevation and large flat areas with gentle slopes are common.

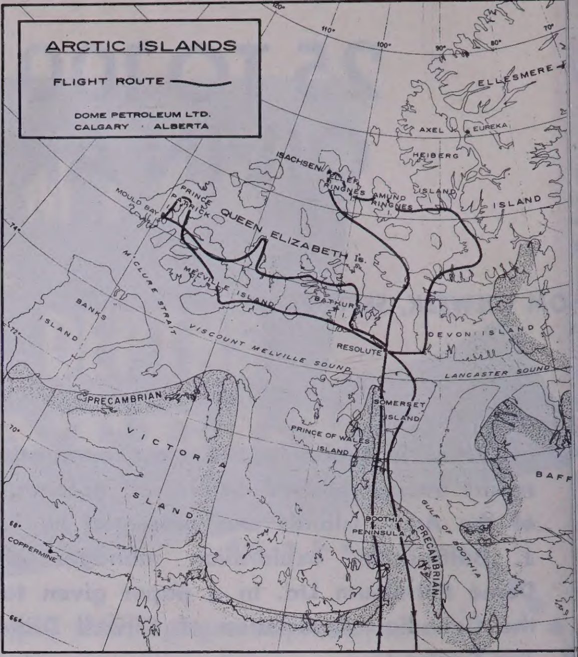
Except for periods of greatest thaw, land travel will be possible without excessive road construction. Light planes even to the size of the Otter can land almost anywhere with little or no runway preparation. Snow is very light even in winter, but drifting snow is a problem. Except for an occasional pocket no snow or ice was seen up to 1,500 feet above sea level. All inland lakes were free of ice and break-up occurs during June. Many inlets and fjords were observed to be free of ice and would be usable by amphibious aircraft.

Submarine transportation of crude oil is certainly a possibility in the near future but the industry will rely on surface equipment and airplanes during the early exploration phases. The Department of Transport is examining Radistock Bay on southwest Devon Island as a potential shipping harbor and air base for civilian use. In time other bases will have to be developed west of Resolute and in the Norwegian Bay area as the oil industry becomes more aggressive in its exploration and development.

Good six months' work period—April to October, with at least four months during this period of constant daylight, will be the best practical work period. Very little snow or rain will fall. Occasional high winds (up to 100 miles per hour) will be bothersome, but it will be surprising to some to learn that the mean wind velocity in the Islands is less than the mean (11.4 m.p.h.) at Toronto. Fog and clouds will be problems, particularly during July and August. Temperatures during the daylight periods range from a little below freezing to about 40° F. Zero can be expected in April and October.

Transportation—This year shipping costs by boat from Montreal to Resolute were $90.00 per ton so that gasoline at Resolute cost 85 cents a gallon and diesel fuel $.75 a gallon. However, there are no facilities for hauling or storage of supplies at this base and one must make plans for this as well as feeding and housing of personnel. If supplies are to be shipped arrangements would have to be made through the Department of Transport. Vessels leave Montreal for Resolute the latter part of July each year.

Permafrost deserves serious respect—Permafrost is the section of the earth's crust where temperatures are constantly below 32° F. At Resolute this zone extends to 1,250 feet in thickness and is coldest at 22° F. from 50 to 75 feet below the surface. To an oil man this is a serious problem in drilling and oil production. In the Point Barrow, Alaska development several holes were lost with drill pipe in the hole when circulation failed and drilling mud froze. Ice shavings raise havoc in mud pumps.



An anomalous situation exists in drilling, in that r frigeration may actually be needed to keep the r foundation frozen to prevent collapse or sinking of t rig due to thawing under it caused by heated drilli mud. There is a great deal of experience now in perm frost drilling in Alaska and Canada and data should studied by drilling contractors hoping to drill on t Arctic Islands.

There are other problems relating to the permafro including the handling of water by pipeline, the buildi of roads and construction of buildings. The main sol tion of the problem for surface installations can summed up as—"Don't let the permafrost melt!"

The permafrost interval causes a high speed layer seismic exploration which makes geophysical work le certain than in other areas.

Conclusion: expensive but not too formidable— a result of our flight and geologic studies, prospecti for oil in the Arctic Islands does not seem to be as fo midable a task as one might think. It is bound to be e pensive and much will need to be learned the hard wa An organization such as the Canadian Association Oilwell Drilling Contractors might consider instituti research of available data for the benefit of its membe and operating companies. The Arctic Institute of Nor America, for example, has on file almost every availab article on the Arctic published in the world and a rangements can be made through this Institute to obta abstracts of all literature on any specific subject desir at a nominal cost.

Because we are bound to see some drilling in t Arctic in the next few years it behooves various se ments of the oil industry to use imagination, thoug and care in planning any program. New methods w have to be worked out in order to keep costs dow Personnel will have to be more carefully screened avoid the peculiar problems that isolation and Arc travel present.

The Arctic Islands may be an area which will give reserves on this continent of an amount to make us i dependent of oil from the Middle East, the Sahara a South America.

The challenge of the Arctic to the oil industry exciting, not only in the hope of reward in the oil to found there, but in the thought that it is such a vi force in extending the frontiers of this nation.

FROM OILWEEK, OCT. 30/59

INDUSTRY LOOKS NORTH FOR TOMORROW'S OIL

By the Editors of *OILWEEK*

The last oil frontier of North America covers more than 200 million acres in the Canadian far north—the Northwest Territories, the Yukon Territories and the Arctic Islands.

A few years ago, considered too remote to warrant active exploration, this vast area has now gripped the attention of the entire industry. Within the next decade oilmen expect the far north country to be a major source of world oil production and reserves.

The following article outlines how the northern exploration pace is gaining momentum, its significance in the eyes of the industry, and the reasons behind the play.

he Canadian far north — the hwest Territories, the Yukon itories and the Arctic Islands— this year gripped the attention he Canadian oil industry unlike hing else before.

ever before has the industry ed to such a vast and virgin area the fervent high hopes and rations that it has attached to nearly 200 million acres of poten- oil and gas bearing areas of the orth. Probably not even the dis- ry of Leduc in 1947 generated e expectations than preliminary nination of the giant structures he Arctic Islands.

) Billion Bbls. in Arctic Islands?

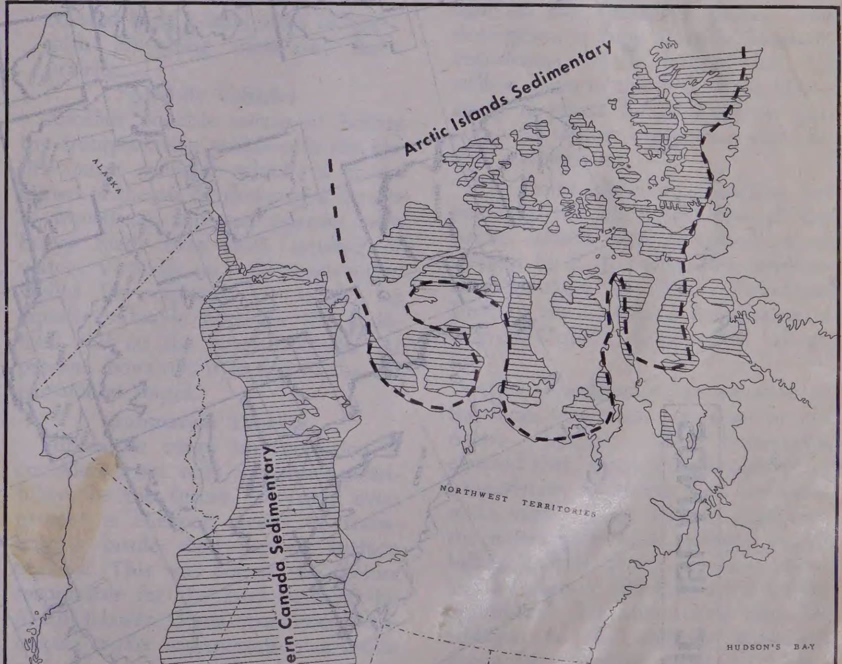
ne exploration manager claims the Arctic Islands have more to mmend them as a potential major province than had the Alberta n in the 1920's, and forecast ulti- e oil reserves here of 25 to 100 on barrels — possibly even more. uring the past year the industry set the stage for an exploration gram in the far north at a record po. Some of the outstanding fac- are:

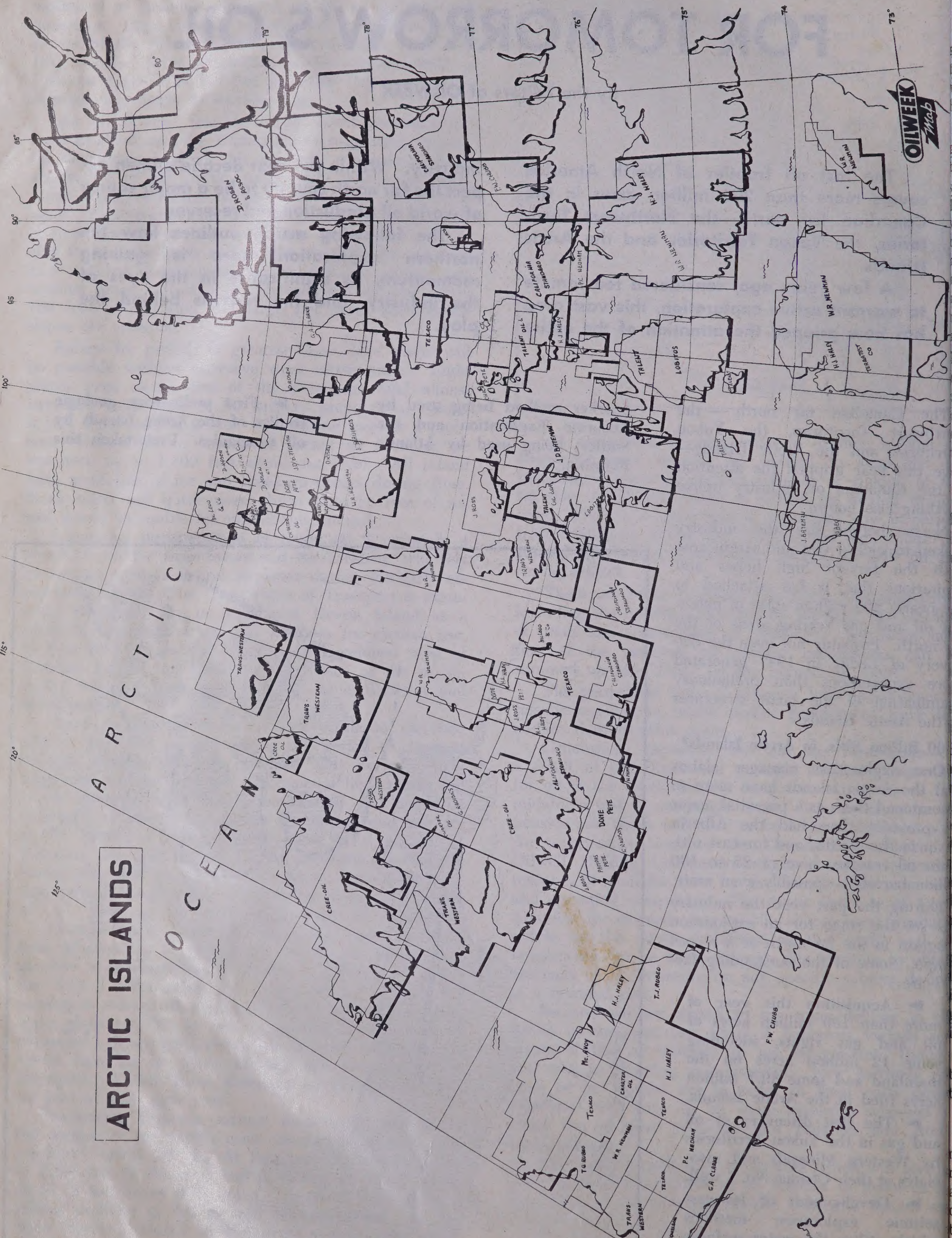
► Acquisition this year of ore than 100 million acres of il and gas rights, including me 12 million acres on the ainland and some 89.7 million cres filed in the Arctic Islands.

► The first discovery of oil nd gas in the Yukon Territories y Western Minerals and asso- iates at their Chance No. 1 well.

► Development of low-cost eismic exploration methods hich utilize the water surfaces overing some 40 percent of orthwest Territories and Yukon erritories. These include the Sparker method being used by Accurate Exploration and the Sniffer, being used by Atlantic Refining.

► First preliminary geologic studies of the Arctic Islands by oil companies. Undertaken this




ARCTIC ISLANDS
ARCTIC OCEAN
OILWEEK Map
125°
120°
115°
100°
95
90°
85°
80°
79°
78°
77°
76°
75°
74
73°
CREE-OIL
TRANS-WESTERN
CALIFORNIA STANDARD
TEXACO
J.D. BATEMAN
W.R. NEWMAN
H.J. HALEY
F.W. CHUBB
T.J. RUBEO
P.C. NEDHAM
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Mc. AVOY
CHARTER OIL
J.W. DONELSON
DOYE PETE
J. ROSS
TALENT OIL
LOBITOS
TERRATEST CO
D. ROSEN & ASSOC.
McLEOD & Co

Land prices reach average $2.11 per acre

ummer, these field studies urned up giant sized structures vith exciting oil and gas possi- ilities.

► Record prices for oil and ;as rights in the Northwest Terri- ories at federal government ales. At three NWT sales in 959 a total of 3,764,221 acres vere disposed of for $7,958,978, r an average price of $2.11 per cre, with a top bid of $8.26 per cre. Two years ago, NWT acre- ge was considered worth not nuch more than a nickle an cre.

'oday oil companies hold rights on e 105 million acres in the North- t Territories and Yukon — an in- se of more than 12 million acres e the end of last year and com- ed with 38 million acres held at end of 1957.

Arctic Islands Land Rush

arly in 1959 a land rush en- ed the Arctic Islands almost by m. In the fastest moving land that Canada has ever seen, the companies to date have filed on e 89.7 million acres. Permits for Arctic Islands land filed upon e not yet been issued by the eral government, pending the es- ishment of new land regulations this area, expected to be an- nced this weekend.

Ieavy exploration expenditure nmitments face the industry in the h country during the next few rs. Expenditure commitments r a five-year period amount to 0 per acre—starting at five cents acre for the first 18 months and easing to 50 cents per acre in the year. This would mean an ex- diture of close to $100 million in NWT and Yukon over a five-year od. Since a substantial portion already been held more than the al 18-month period, the pace will considerable tempo this winter, easing each year.

similar expenditure is faced in Arctic Islands — only spread over e as long a period of time.

Limited Drilling To Date

o far, exploration work in the h has consisted primarily of seis- and exploration studies, with only ry small amount of actual wildcat ing. The usual pattern has been conduct geologic studies during summer when the ground is un- lened of snow, and drilling and nic operations during the winter when equipment can be moved in over the frozen muskeg. An exception to this has been the drilling operations carried out by the Western Minerals group in the Peel Plateau area of the Yukon. The drilling rig is kept in the area permanently, and rig moves are made and supplies and equipment brought in by tractor-train during the winter months, with actual drilling carried out during the summer.

This winter a record number of wildcats are expected to be started in the Yukon and Northwest Territories, possibly as many as half a dozen. Next winter the number will be even greater.

Transportation is the big cost factor in northern exploration, because of both the long distances involved and the rugged muskeg conditions. Marked advances are being made in the development of new muskeg vehicles which promise in time to bring northern transportation costs at least a little more in line with prevailing costs on the prairies.

Air-Lift Vehicles

Another possible means of licking the transportation problem is the air-lift cargo vehicle, which is maintained in the air by downward thrusts of forced air and can operate with heavy loads over land, muskeg or water. Virtually no road construction would be required. It would be equally valuable both on the mainland and on the Arctic Islands. At present, however, it is still in the experimental stages.

Submarine Tankers

Submarine cargo transportation is considered not only a distinct possibility for the future, but may even present a cheaper means of transporting crude than present surface tankers. This was one of the factors responsible for the land rush in the Arctic Islands. Given economical submarine tanker transportation of crude and the Arctic Islands are relatively close to major markets. It is less than 3,000 miles from the Arctic Islands to England, less than half the 8,000 miles from the Persian Gulf, where Europe draws the bulk of its oil supplies.

Potential market outlets for any oil developed in these remote areas does not appear to be worrying the industry. It will likely take a good many years before appreciable reserves and production capacity are developed. By that time, the industry expects that the present position of world wide crude oil surplus and fierce competition for markets will be virtually over. Within the next 10 to 15 years, world oil demand is expected to double from its present rate of less than 20 million b/d to close to 40 million b/d. That extra demand of 20 million b/d will require the finding and developing of a lot of new oil reserves.

Geologically, the prospects for big oil and gas accumulations are considered excellent, both on the mainland and on the islands.

Biggest Structure?

On the mainland, Home Oil and associates plan to drill this winter on the North Petitot structure, a few miles north of the British Columbia border. This structure has been described as the largest indicated structure on the Canadian plains. The description is from Canada Southern Petroleums which farmed out 1.2 million acres in the area to the Home group in return for $3.5 million cash and a $3 million exploration expenditure commitment.

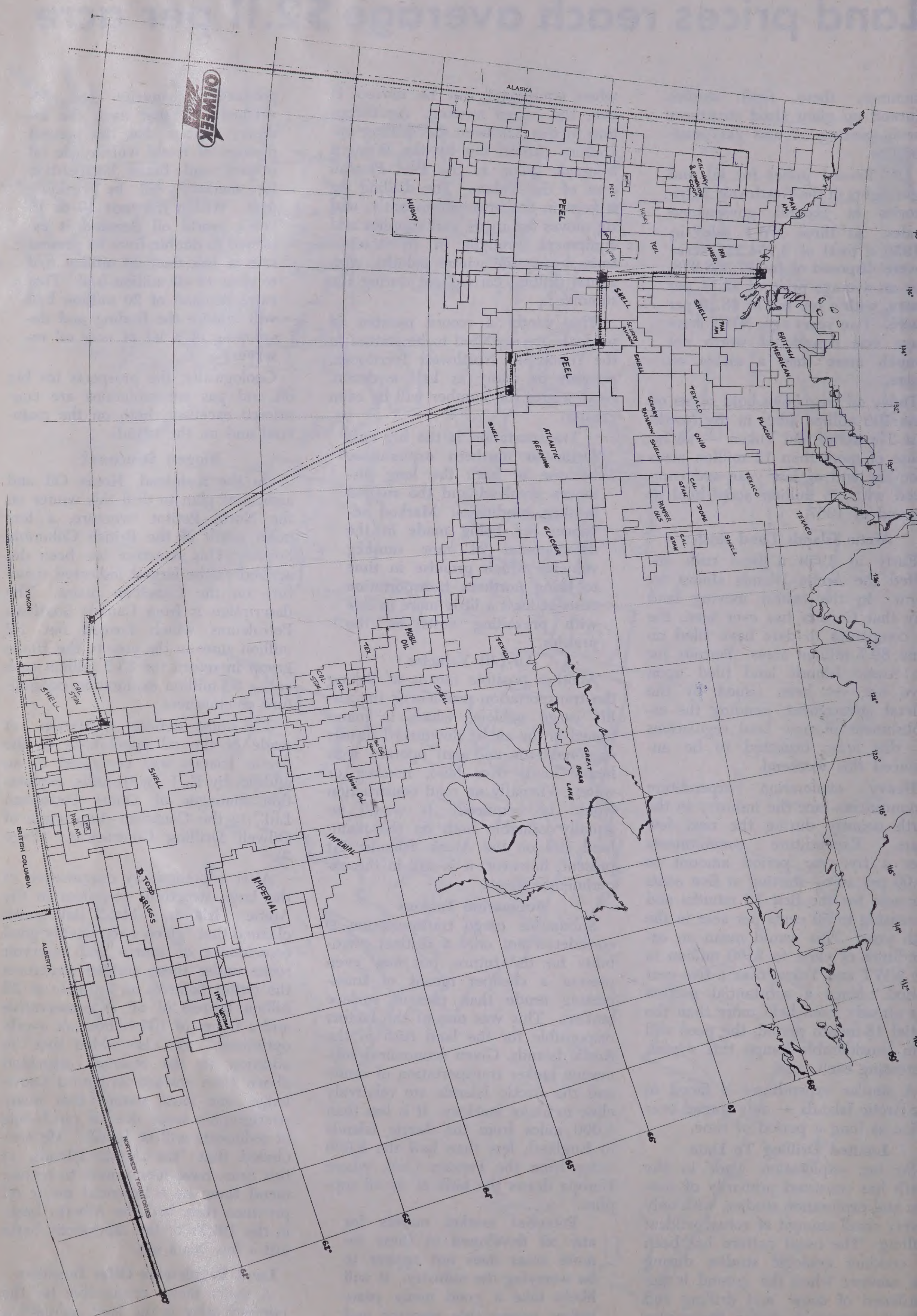
The most definite indication yet made of the oil possibilities of the Arctic Islands was contained in an address by E. J. Baltrusaitis, exploration manager of Dome Petroleum Ltd., to the Canadian Association of Oilwell Drilling Contractors. (Page 3).

After a preliminary examination of the large structures prevalent in the Arctic Islands, Mr. Baltrusaitis claimed that "given a reasonably good coincidence of source and reservoir rocks under these surface structures the writer believes an estimate of 25 billion barrels of oil is conservative and a figure of 100 billion not overly optimistic." He also added that "in addition to the reserves estimated above from surface structural knowledge, one must assume that many stratigraphic traps due to pinch-outs of sediments will be found." He concluded that "the Arctic Islands, at this time, have much more to recommend them as a potential major oil province than had the Alberta basin in the 1920's or the Mackenzie basin just a few years ago."

Land Regulations Offer Incentive

A major factor responsible for the northern play is the land regulations

Land prices reach average $2.17 per acre



LAND HOLDINGS IN NWT AND ARCTIC ISLANDS

Following is a list of the major land holders in the
rthwest Territories, Yukon Territories and Arctic
ınds, and the amount of acreage they hold.

NWT Holdings

Northwest Territories and Yukon—Amerada
77,900; Atlantic Refining, 8,455,100; British
ıerican, 3,043,000; Banff Oil, 448,100; Cali-
nia Standard, 7,042,000; Consolidated Mic Mac
is, 1,790,000; Canadian Homestead, 405,934;
arter Oil, 522,000; Calgary and Edmonton Corp.,
1,900; Champlin Oil and Refining, 377,000; Con-
st Exploration, 771,000; Canadian Northwest
ploration Mines Ltd., 420,000; Dome Petroleum,
35,000; Great Plains Development, 418,000;
ıcier Explorers Ltd., 1,296,000; Canadian Husky,
4,000; Honolulu Oil Corp., 314,000; Hunt Oil
d Placid Oil, 3,450,000; Home Oil, 1,224,000;
burmum Explorers, 534,000; Mobil Oil, 1,708,-
0; New Superior Oils of Canada, 185,000; Ohio
l, 976,000; Pyramid Oil and Gas, 927,000; Petcal
. Ltd., 179,000; Placid Oil Co., 1,446,000; Ran-
rth Exploration, 356,000; Shell Oil of Canada,
,000,000; Sun Oil, 429,000; Scurry-Rainbow,
3,380,000; Siebens Leaseholds, 338,000; Texaco Exploration, 4,992,000; Triad, 338,000; Texaco Canada, 2,807,000; Tennessee Gas Transmission, 188,000; Union of California, 2,258,000; Woodley Canadian Oil, 453,000; Western Decalta, 580,000; Western Minerals et al, 6,134,000; Imperial Oil et al, 1,396,000.

Arctic Islands

Arctic Islands. (Permit acreage applied for)—Dominion Explorers, 3,725,000; California Standard, 9,054,000; Cree Oil, 7,388,000; Charter Oil, 1,182,000; F. W. Chubb, 3,551,000; G. A. Clarke, 1,418,000; Chican Petroleums, 437,000; Dome Petroleum, 1,061,000; H. J. Haley, 3,987,000; Lobitis Oilfields of Canada Ltd., 2,763,000; C. M. McAvoy, 2,846,000; McLeod & Co. Ltd., 1,729,000; J. Hirschorn, 12,270,000; P. C. Nedham, 977,000; J. W. Powelson, 899,000; Pampas Petroleum, 828,000; J. Ross, 1,005,000; G. Radisics, 1,498,000; D. Rosen and associates, 10,178,000; T. J. Rubeo, 1,443,000; Texaco Canada Ltd., 2,990,000; Trans Western Oils Ltd., 12,667,000; Talent Oil & Gas Ltd., 3,200,000; Terratest Co. Ltd., 1,378,000.

the federal government, designed
encourage the oil companies to
rticipate. Land deposits made with
government on permit acreage are
undable in full on completion of
ploration expenditures equal to the
ount of the deposit. As the land-
n for one oil company described
"This results in the cheapest land
y in the world." Land carrying
sts — a major item of expenditure
the prairie provinces — are virtu-
y nil in the north.

Existing regulations covering the 105 million acres which have been issued in the NWT and Yukon Territories call for a deposit of five cents per acre and a fee of $250 per permit. The permit is in force for a period of 18 months, and the five cents per acre is refundable at that time if the permit holder has carried out exploration work to the value of five cents per acre. The permit is renewable for a further 18 months with a deposit of 25 cents per acre. After that, the permit is again renewable for a further six years, with a deposit of 30 cents per acre for the first year of the six-year period, 40 cents per acre the next year, and 50 cents per acre thereafter.

Any permits which are surrendered may be auctioned off by the government.

Net effect is that permits carry an expenditure of 30 cents per acre for the first three years, increasing 10 cents per acre each year thereafter to a maximum of 50 cents per acre, and may be held for as long as nine years before being converted to lease.

Permits are convertible to lease—with approximately half the acreage reverting to the government—upon the development of commercial production. The lease selections, however, may be taken out in larger blocks than in Alberta. The permit holder may select lease blocks measuring five by three sections or four by five sections. A royalty of 6¼ percent of gross production is payable for the first three years of production, increasing to 12½ percent thereafter.

Lease Rental May Be Reduced

Lease rental is at the rate of 50 cents per acre (not refundable) for the first year and $1.00 per acre each year thereafter. These lease rentals, however, may be considerably reduced. One half of the amount of exploration expenditures made on a permit in excess of the deposits may apply in lieu of lease-rental payment. Under this system it is quite likely that a lease holder who carries out extensive exploration work before finding commercial production, will have no lease rentals to pay for quite a number of years.

The regulations for the Arctic Islands — for which the industry is eagerly awaiting — are expected to be similar to those in force on the mainland, with the exception that the exploration commitments will be spread over twice as long a period of time.

FROM OILWEEK, NOV. 6/59

WILL ARCTIC OIL BE

That's what new regulations for north country will produce claims Northern Affairs Minister Hamilton

Agreement between the CPA and Northern Affairs Minister Alvin Hamilton on the time element involved in releasing results of northern seismic programs in 1959 cleared away a major obstacle to exploration efforts in the far north.

During the discussions, Hamilton outlined the government's northern oil policy, designed to yield the lowest-cost oil in North America. Low cost Arctic reserves are essential, Hamilton claims, if a slice of the growing world oil market is to be captured within the next decade.

Hamilton expressed confidence that the industry will be able to find and develop low-cost oil in the north, capture substantial markets, and solve the difficult transportation problems. New transportation methods —such as atomic oil submarines—were mentioned as vital to the northern development program.

Discussion in 1959 in Calgary by Northern Affairs Minister Alvin Hamilton and the Canadian Petroleum Association are believed to have resolved a major point of dispute in new—almost revolutionary—regulations proposed by the federal government. Prime objective of the regulations will be the development of oil reserves in the far north and the Arctic Islands at a cost lower than anywhere else in North America.

As part of the policy designed to yield low cost oil, the department of northern affairs' new regulations for the north proposed that information from all seismic programs be released within a period of two years, contrasted to the five-year period in force in Alberta. Purpose was to avoid duplication of seismic effort and expenditures, thereby helping to lower costs.

Would Eliminate Incentive

Releasing of seismic information within a two-year period met stiff opposition from the industry, which claimed that it would eliminate incentive to carry out seismic work in the north, and drastically reduce the exploration efforts.

"It would pull the plug right out from under exploration efforts in the north," claimed one CPA member.

The dispute on the time element involved in releasing seismic information has been responsible for holding up the new northern regulations which, according to Hamilton, have been ready for promulgation since last May. And because the new regulations have not been promulgated, the federal government has not yet been able to issue the 90 million acres of permits that have been applied for on the Arctic Islands.

Five-Year Waiting Period

Following discussions with the CPA, Hamilton is reported to have agreed to a five-year waiting period before seismic information must be released. As a result, the new northern regulations are expected to be promulgated shortly, following which the government will be able to issue permits on the acreage applied for in the Arctic Islands.

In a prepared statement to the CPA and at a news conference Hamilton outlined the federal government policy designed to yield low-cost northern oil. Key points:

► The drilling of the minimum number of wells necessary to effectively drain a given reservoir.

► Low cost land acquisitions.

► Large government expenditures on a program of northern road construction to help reduce exploration costs.

► Government assistance with other problems of northern communication and transportation.

Will Enforce Unitization

Enforced field unitizations will eliminate the need drill surplus wells in order to protect against reserv loss from adjacent production. Large lease blocks w help remove incentive for excess drilling. "We propos to revise our lease regulations slightly to assure that ve small parcels of land, less than one to two sections in siz are not held under lease," Mr. Hamilton told the CPA.

"I can assure you that it will not be our policy to force uneconomic drilling. We should certainly attempt to avoid drilling of so many wells that excess proration results. We will consider, and continually bear in mind, the importance of economic production of oil in the manner of Crown reserve disposition."

Low land costs will apparently be another factor the program of low oil costs. He told the press confe ence that "Alberta land prices are out of sight. Northe land costs are cheap. We intend to keep them cheap He did not explain how land costs would be kept lo under a system of competitive bidding for acreage.

Won't Seek Quick Dollar

But he did state that "we will not be out for the quic dollar through the sale of oil and gas rights. The mo money that is spent on land acquisitions in the earl stages of the exploration program, the less there is avai able for actual exploration work and development. Th government—and the people of Canada—will get the fair share of the return later—once production has actuall started—and on a longer term basis. This will yield th greatest return both to the industry and the country a a whole."

EST IN AMERICA ?

Improve Communication

He also told the CPA that "studies are now under y to devise systems to greatly improve communication oughout the oil exploration areas. Meetings will be anged between oil company representatives, officials the department of transport, and my department to ure that practical steps are taken soon.

"When large scale exploration gets under way in the tic Islands, improved airstrips and port sites will be eded as service centres for the industry. The govern- nt is prepared to do its share in financing these studies," l will "also be prepared to co-operate with industry in earching and meeting some of the problems of northern transportation."

The minister emphasized the need for low-cost north- reserves if production from this area is to obtain a e of the growing world oil market. "The key to early thern oil and gas development must lie in producing the lowest cost possible. If we do not adopt policies achieve low cost oil, then it appears likely that north- oil cannot be marketed within the next few years erefore, it is mandatory that we adopt policies to ieve this low cost oil," he told the CPA.

CPA AND HAMILTON REACH AGREEMENT

A statement issued jointly by Alvin Hamilton, minister of northern affairs and national resources, and John W. Proctor, general manager of the Canadian Petroleum Association states that, following a meeting with the association's board of governors in Calgary, many differences of opinion have been resolved on the over-all subject of oil and gas regulations for the Northwest Territories and Yukon.

Details of the proposed government regulations were discussed in frank detail and in many instances agreement was reached. There are a number of problems which both parties agree should be studied in further detail by the association, after which their recommendations, which may be helpful to the minister and to the federal government in the final framing of regulations, will be forwarded to Ottawa.

Commercial Production in Seven Years?

Despite the present world oil surplus, Hamilton ex- essed optimism concerning the prospects of marketing ctic oil within the next few years, and inferred that mmercial production and marketing may be achieved thin seven years, with commercial discoveries being ade within possibly three years.

New means of transportation will play key roles in the northern oil development, according to the minister. He particularly mentioned the possibility of atomic submarine tanker transportation, and pointed out that Europe lies only 3,000 miles from the Arctic Islands, compared with 8,000 miles to Europe from the Middle East, presently Europe's main petroleum supply source.

"The key . . must lie in producing at the lowest possible cost."—Hamilton.

"Even the large Sahara oil discoveries will not meet Europe's growing oil needs in the future," Hamilton declared. He added that he did not think that Venezuelan oil would present too great an obstacle for Canadian Arctic oil in competition for world markets.

Hamilton's hope of securing a market for northern oil appears to be pinned on a steady growth rate of world petroleum demand which he stated he believes will correct the present demand-supply imbalance "within the next two or three years" and will double the free world's oil demand within the next 15 years or less.

"If we can get our northern costs down—as I believe we can—we will be able to compete for offshore markets," he declared.

In response to a question, Hamilton provided a possible clue on government thinking on the proposed crude oil line to Montreal, and one reason why the government is likely to oppose it.

"If the Montreal line means a tariff or quota on petroleum products imported into Canada, then it would adversely affect the prospects of capturing a portion of the world market for crude oil produced from the Arctic Islands."

Other officials of the department of northern affairs are reported to have indicated the possibility of supplying the Montreal market at a later date with crude from the Arctic.

Will Establish Conservation Board

Hamilton forecast the establishment of a federal conservation board whose duties would be separate from the administration of oil and gas lands. "It would be a semi-judicial body of experts to advise the minister, and its work would be correlated closely with the work of the National Energy Board."

Hamilton made it abundantly clear that government policy will be designed to foster active Canadian participation in the northern development—in fact to an extent which may bring criticism from the industry of unfair prejudice.

In this regard, Hamilton outlined "some of the ways" in which the government may dispose of its Crown reserve acreage: (1) Lease the rights to the highest cash bidder; (2) to the highest royalty bidder; (3) a system of fixed royalty and cash bid, and (4) "have regard to the financial responsibility and financial structure of the bidding companies and take into account the extent to which Canadian capital will have an opportunity of participating."

This latter method would represent a radical departure from present methods of Crown land disposition and may result in strong opposition from the industry.

Modified Reservation System

(Continued on Page 21)

FROM OILWEEK, NOV. 6/59

NWT SURVEY PROVES VALUE OF NEW SEISMIC METHODS

By A. E. PALLISTER
Accurate Exploration Ltd.

A preliminary survey along the Mackenzie River by Accurate Exploration has indicated great potential for low-cost marine seismic work in the Northwest Territories, an area 40 percent covered by water.

Accurate used both conventional marine seismic methods, plus the new Sparker method, which provides a continuous geologic profile to a depth of 800 feet or more below the river bottom.

In the following paper author A. E. Pallister concludes that these two methods offer an invaluable method of carrying out preliminary geophysical surveys at exceptionally low costs.

The developing interest generated in the Northwest Territories during the past two years prompted a seismic river survey in the Mackenzie River—a means by which the Northwest Territories could be rapidly explored on a preliminary basis. Since for years in the Northwest Territories the main means of transportation was by rivers and since the primary drilling that has taken pla has been closely associated with the major rivers, geophysical survey restricted to the environments of t water transportation would appear to be a means of fir ing structures which could be drilled most easily consid ing their ready accessibility. The only developed

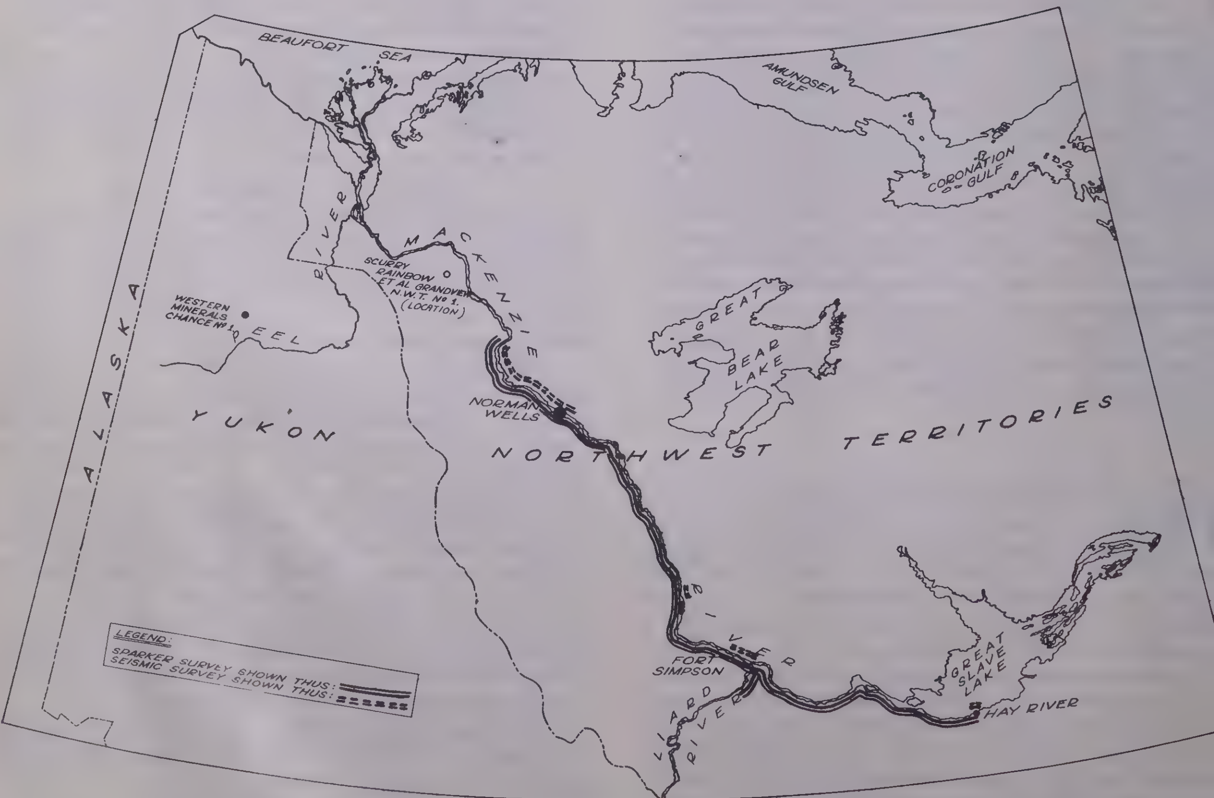


FIG 1. LOCATION OF SPARKER AND SEISMIC MARINE SURVEY

ACCURATE EXPLORATION
SUMMER 1959.

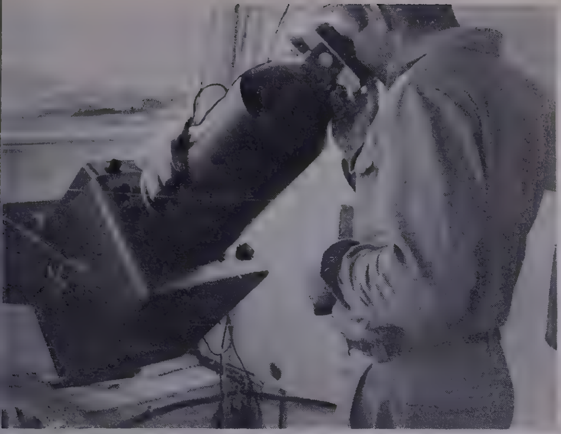


FIG. 2—Radar and photographic equipment used for recording location.

d in the Northwest Territories, Norman Wells, is ated on the banks and on an island in the Mackenzie er, some 600 miles north of Hay River. Some 34 dcat wells have been drilled alongside the Mackenzie er north of Great Slave.

Figure (1)—shows the location of the Sparker and smic Marine profiles carried out during the summer of 59. A continuous Sparker line was recorded from Simpson to San Sault Rapids. It is anticipated that survey will be continued to the Mackenzie Delta dur- the summer of 1961.

Research Stage

Before proceeding with the survey several months e required to plan the logistics of the operation and earch was done on the type of boats required and the hod of conducting a Seismic Survey. Of equal im- tance was the obtaining of personnel experienced in rivers of the NWT. Although seismic operations have n widespread in off-shore operations very limited ounts of seismic has been conducted in rivers. For reason experimentation was carried out through the in the Mackenzie River in the spring of 1959, and followed by further experimenting in the Bow River North Saskatchewan River in Alberta. During the erimentation the problems of river noise due to the rent were the main problems to be tackled. Various types and configurations of geophones were used and several methods of detonating charges were carried out. One of the types of charges successfully used was ammonium nitrate (commercial fertilizer). Finally after a great deal of experimenting successful records were recorded in the North Saskatchewan River just east of Edmonton. During this trial shooting in the river members of the Alberta Government were in attendance to observe the effects on fish and wild life. After advising the government of our plans the Dominion Departments of Fisheries, Northern Affairs and Transport were most co-operative in providing assistance and permission to carry out the program.

Marine Survey

The final seismic method developed was the use of a floating seismic cable with multiple pressure-type geophone with the output being recorded on magnetic tape. By carrying out a totally marine survey the seismic crew was able to cover the mileage in a day that would be normally covered by a land crew in a week. The dynamite was suspended in the water by means of balloons and detonated in the water eliminating the need of any drilling equipment. Having been able to establish the feasibility of using seismic as a marine exploration tool the Sparker instrument was investigated as an addi-

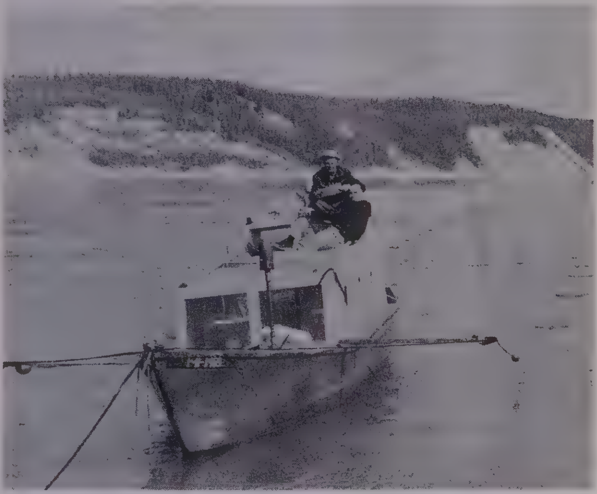
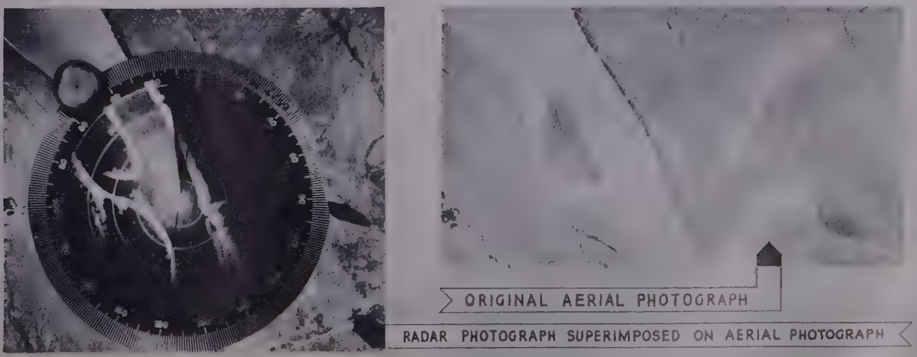


FIG. 4—Sparker boat in operation along the Mackenzie River.

FIGURE 3


ORIGINAL AERIAL PHOTOGRAPH
RADAR PHOTOGRAPH SUPERIMPOSED ON AERIAL PHOTOGRAPH

RESULT OF RADAR PHOTOGRAPHY SHOWING COMPARISON WITH AERIAL PHOTOGRAPH

ACCURATE EXPLORATION LTD.

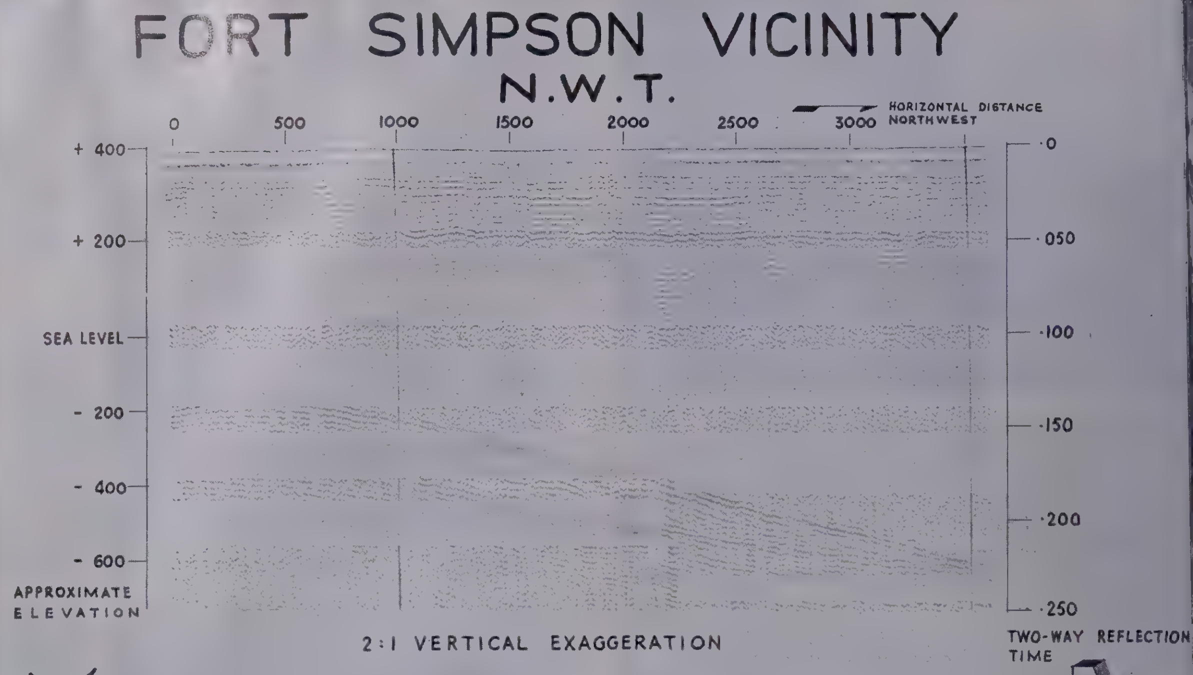


FIGURE 5 CONTINUOUS SPARKER PROFILE

ACCURATE EXPLORATION LTD
JULY 1959.

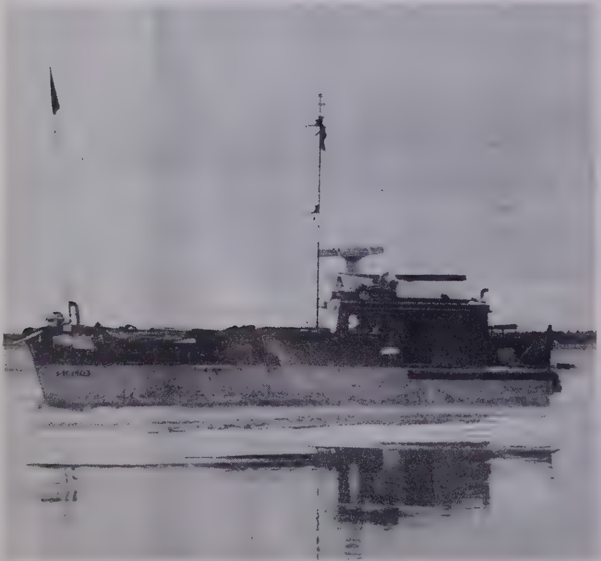


FIG. 6—Seismograph recording boat — a converted shallow draft landing craft.

tional tool for the initial exploration of the Mackenzie River. The Sparker was developed at Woods Hole Oceanographic Institute in Massachusetts by J. B. Hersey and S. T. Knott, and has been licensed exclusively to Marine Geophysical International Inc., of Houston, Texas. Dr. Charles B. Officer, who heads Marine Geophysical International, has licensed Accurate Exploration Ltd. to use the Sparker system in Canada.

The Sparker emits a 12,000 volt electric spark or
explosion with about the intensity of the same order
a blasting cap. The device is able to obtain continuo
reflections to a depth of as much as 1,400 feet belo
the surface of the water by use of this spark seism
source. These discharges are triggered to take place
quarter or one-half second intervals and are triggered
correspond to a zero mark on the paper record. Th
result is a measurement of the time that the signal requir
to strike a reflective surface and return to the hydropho
receiver. Since these discharges take place continuous
the record takes the form of a continuous cross-secti
giving the profile of the base of the sea floor and refle
tive geologic horizons beneath the bottom. The spa
signal is generated by a large transformer and rectifi
tube which charge condensers. The condensers dischar
through a spark gap trailed behind the survey boat. Th
Sparker was used in the North Saskatchewan River a
after experiencing difficulties with river side and sa
bar reflections and river noise, true sub-bottom reflectio
were eventually recorded.

Surveying Problem

The final problem of research was one of surveyin
This was solved by installing a short-range radar set
the survey boat equipped with a simple lens reflex came
(Figure 2) which photographed the radar screen alo
with a time reference. As the Sparker profile was r
corded a timing device automatically recorded the recor
ing time on the Sparker record for eventual correlati
between the radar photograph and the Sparker profi
Figure 3 shows the result of the radar photography wi
a comparison with an aerial photograph. By this mea
the location of the boat can be accurately located in t
river.

The Survey

A successful continuous Sparker profile was co

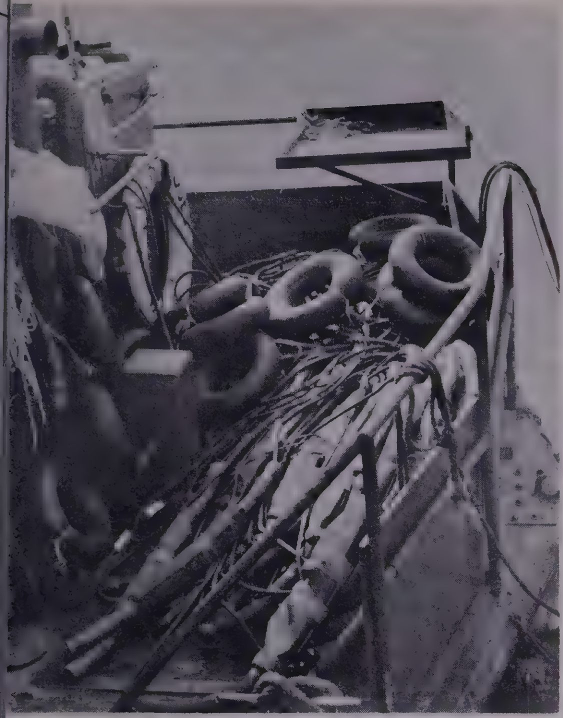


FIG. 7—Marine geophone cable. Inner tubes provide flotation.

nced at Ft. Simpson, and 400 miles down the Mac-zie River. The recording technique was developed the 200 miles between Hay River and Ft. Simpson gure 4). Generally the line of profile was a straight in the main navigational channel although from time time detailed control was obtained by zigzagging the trument back and forth across the river. Marine seismic filing was carried out in conjunction with the Sparker, not on a continuous basis. Continuous seismic pro-ng was carried out in short line segments at spaced ervals along the river in order to give an over-all ication of the results of the method and to detail ictures shown by the Sparker.

The survey party consisted of one seismic recording t, one housing boat (both converted landing craft), one foot Sparker recording boat, a supply barge, and one foot shooting boat—powered by a 35 h.p. outboard tor. The crew of 10 men consisted of a party man-er, seismic operator, Sparker operator, two surveyors, oter, mechanic, cook and two river pilots.

The Sparker survey included a two day detail pro-ng pattern in the vicinity of the Norman Wells oil ld. At Norman Wells, seismic lines were carried out various parts of the river from the Radar Island Well oss the Norman Wells field with two lines north and line south of Bear Island. In addition to the detailed ofiling across this reef field refraction shots were re-rded to give an indication of the near surface velocities neath the river.

Problems Encountered

The main problems involved in operating far remote ches were of course one of the values of conducting s type of preliminary survey. Other than the technical oblems involved which eventually were solved, other oblems which were experienced were communication, nsportation and weather. While the communication system is quite reliable to such places as Norman Wells and Ft. Simpson the problem of communicating with a crew remotely distant from the D.O.T. stations is extreme. Commercial air service is provided in the area. The weather is a large factor to be contended with in operating in the northern part of Canada. Many days were experienced where work was not possible due to the high winds and fog. While these considerations would not hinder a land crew particularly, the use of aircraft, helicopters and boats is limited by the weather.

Results — Sparker

Having solved the river noise and side reflection problems successful Sparker profiles were recorded over a large percentage of the river. Isolated areas understandably contained no reflective horizons within the range of the method. Figure 5 shows a portion of a Sparker profile with a reflection within an Upper Devonian formaation which shows a dip of 400 feet to the northwest in 3,500 feet of horizontal distance. Penetration with the Sparker reached a maximum of 1,400 feet to 1,600 feet. Good reflections were recorded from the Imperial Formation near Norman Wells and from beds within the Fort Creek shale. These reflections are quite useful in mapping the Norman Wells Reef. In the upper part of the river where near the surface beds within the range of the Sparker instruments were mainly Simpson shales, reflections were recorded which while not carrying continuously were consistent enough to facilitate the use of a phantom horizon for mapping purposes. Using these phantoms, well ties could be made and ties between wells were quite successful anticlines, synclines, faulting and indicated reef development in addition to the configuration of the bedrock were mapable. One important interpretation consideration is that of the Paleozoic surface which in most places gave a good reflection and in some cases returned virtually all the source energy. Mostly, however, horizons beneath the Paleozoic erosional surface could be carried and in these places these reflections prove most valuable in that they are probably conformable with underlying formations.

Seismic

Figure 6 shows the seismic recording boat in operation. The recording instruments are contained forward in the

FIG. 8—Seismic shot being detonated at the edge of the Norman Wells oil field.

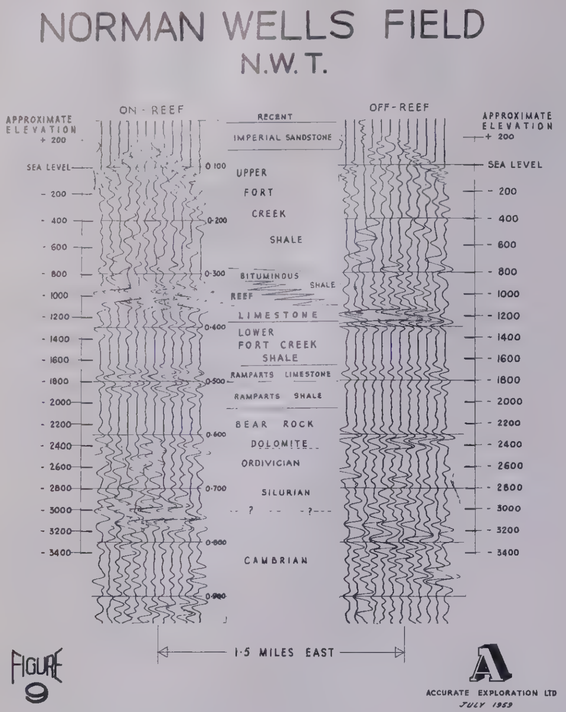


FIGURE 9

MARINE SEISMOGRAM COMPARISON
(WITH ESTIMATED GEOLOGICAL CORRELATION)

hold of this converted landing craft. Note the radar and radio communication antenna. Figure 7 shows the marine seismic cable stored on the aft part of the recording boat. The inner tubes were used to float the cable. Each of the boats shown contain two geophones. A total of eight geophones were used for each recording trace. Figure 8 was photographed on the east flank of the Norman Wells oil field. A shot of this type was detonated at 700 feet intervals along the river. In the background can be seen Bear Island. Seismic was recorded in the Hay and Mackenzie Rivers and after considerable experimentation and developing of river noise cancellation methods the seismic results are portrayed in Figure 9. This illustration shows the comparison of a seismic record recorded on reef, and another recorded off-reef (near the shot being fired in Figure 8). Note the extreme change in the Fort Creek section where on the left a reflection from the Norman Wells Reef is recorded at approximately 0.320 seconds and on the off-reef record a reflection of the reef limestone is recorded at approximately 0.370 seconds. The Rampart Limestone reflection, however, is recorded at approximately the same reflection time (.480 seconds). These two records are approximately 1.5 miles apart and the continuous profiling between the two displays the reef flank very clearly. Continuous cross-sections and variable density presentation of these "across the reef" lines is presently being prepared. In some areas river sediments caused poor record quality, however, by increasing the amount of dynamite and changing the depth of the charge in most cases satisfactory records could be recorded. Considerable seismic work was performed in the river between Norman Wells and San Sault Rapids—a very interesting area geologically.

Conclusions

In addition to providing a means of correlating back to the known by seeing what results can be obtained across the Norman Wells Reef, and between other wells
in the vicinity of the river, the Sparker and Seismic p
filing is considered to be a good method of hi-gradi
large Northwest Territory permit blocks in the init
stages at relatively low cost. It is estimated that Mari
Seismic can be carried out at one-half the cost per m
and Sparker can be carried out at one-eighth the co
per mile of conventional Land Seismic Surveys. Thus
a preliminary tool in planning a geophysical progra
prior to the large scale operations involving bulldoze
track vehicles, and involved drilling which will be us
in the eventual geophysical exploration, the Marine Se
mic and Sparker methods seem to be valuable sin
accessibility to many of the Northwest Territories perm
blocks can most readily be provided by either rivers
landing on lakes by air. This method in the Northwe
Territories appears to be a natural in providing a pr
liminary survey to proceed the large scale programs whic
will follow in years to come.

FROM OILWEEK, FEB. 27/60

Will Use New Method

Accurate Exploration Ltd. will use the new gas explosion method to conduct marine seismic operations in the Northwest Territories this summer, A. E. Pallister of Accurate told OILWEEK.

The company will also conduct conventional marine seismic surveys from north of Norman Wells to the delta of the Mackenzie River, as well as off shore from the mouth of the river in the Arctic Ocean.

It is believed that this will be the first time that marine seismic surveys have been taken in the Arctic Ocean off the Canadian mainland for oil and gas exploration.

The marine seismic surveys will be under contract to an oil company, but who the work will be done for has not yet been revealed. The marine survey, using the gas explosion method, will be to evaluate this recently developed method. Mr. Pallister stated that Accurate will use a gas explosion method similar to that developed by Rass of the Woods Hole Oceanographic Institute in Massachusetts.

The gas explosion method will replace the Sparker method which Accurate used to obtain continuous geological profiles along 400 miles of the Mackenzie River last summer. Primary advantage of the gas explosion method is the greater depth penetration. With the Sparker Survey, Accurate obtained a maximum depth penetration of 1,600 feet. With the gas explosion method this summer the company hopes to obtain depth recordings to 5,000 feet using several hydrophones for recording. "We feel that we should be able to at least double the depth penetration attained by the Sparker," Mr. Pallister stated.

OM OILWEEK, NOV. 13/59

AIRBORNE MAGNETOMETER SURVEYS USEFUL IN NORTH

H. WAYNE HOYLMAN,
Consulting Geophysicist

M. E. ERFLE,
Spartan Air Services Limited

With the development of oil and gas activity in the Canadian north, airborne magnetometer surveys are coming into their own. Today, the airborne magnetometer is generally accepted as one of the better geophysical instruments for reconnaissance exploration in the industry. Until three or four years ago only small areas in the north had been surveyed by this method. Since then, large tracts of land have been covered in an attempt to keep pace with the rapid acceleration of interest in this part of the country. As techniques are improved, oil men agree that airborne magnetometer surveys will become an increasingly vital tool in the north.

Airborne magnetometer surveys have been successfully ied out throughout the past 10 years in various parts he world, in an effort to help isolate areas of interest, the petroleum and mining industries. Today the orne magnetometer is generally accepted as one of better geophysical instruments for reconnaissance exation in the oil and gas industries.

Until recently the greater portion of the surveys were g conducted primarily in the middle latitude; how-, because of the increased interests in sedimentary inces in Canada's northland, exploration has been ped up in these areas, and the airborne magnetometer eing effectively used in geophysical exploration. Until e or four years ago only smaller areas in the north e surveyed by this method, but since then large blocks e been surveyed by the petroleum companies and the eral division of the federal government.

Vith the Dominion observatory having diurnal base ons located in these northern regions, a better appreon of diurnal magnetic variations and magnetic storms been made possible, and this information is being to advantage with the magnetometer surveys of e blocks of areas.

'o assure that diurnal magnetic effects are more posiy eliminated or minimized during the compilation of magnetic data, a technique using absolute recording uments both in the aircraft and on the ground has e into use in recent surveying. An explanation of method is covered later.

. W. Morley in his paper in the American Geophysical n, Vol. 34, No. 6, December, 1953, discussed a etometer survey made in northern Alberta, which ates that magnetic disturbances are not uniformly r over a large area. It was found that the maximum rture from linearity over any 10-minute period during these disturbances varied from 10 to 38 gamma on a line in an east-west direction and approximately 87 miles long. Also, on a north-south line approximately 130 miles long, the maximum departure from linearity over any 10-minute period during these disturbances varied from 28 to 80 gamma.

It can be seen from this, that using only a storm monitor at the airport for field survey operations is not reliable for determining conditions several tens of miles away at the survey block.

Previous Control System

When the airborne magnetometer first was accepted as a geophysical instrument, a system of control had to be devised to try to eliminate from the recorded data the effects of daily variations. With the original instrument being the flux-gate type, relative changes in the earth's magnetic field were recorded. This meant that a cer-

This magnetometer equipped MK V Anson, with d in tow, conducts a geophysical survey for oil er central Alberta.

Accurate photo-mosaics such as above greatly assist in obtaining good horizontal control for northern magnetometer surveys.

tain amount of additional flight control lines were required transverse to the traverse lines in order to establish a magnetic datum plane to which the traverse lines (original profiles) are tied.

Since specifications for the survey work were written to allow the survey to proceed under conditions of moderate linear diurnal variations, it was necessary to fly a system of short lines or profiles around the periph of the survey area. Fig. 1 shows the chain-stitch p tern of flight lines or base loops on the periphery, spacing of the cross-tie lines is usually six miles. H ever, on some surveys in the past this distance has b increased. It is to be noted that on the base loops duration between intersections is between five and minutes. From experience during the past years, t system was quite adequate for surveys made in the m latitudes and under suitable conditions in the provinc latitudes in Canada.

In a survey using absolute reading (Varian) inst

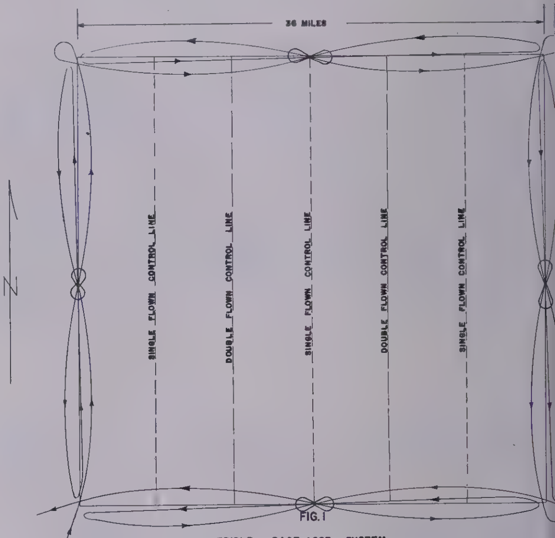
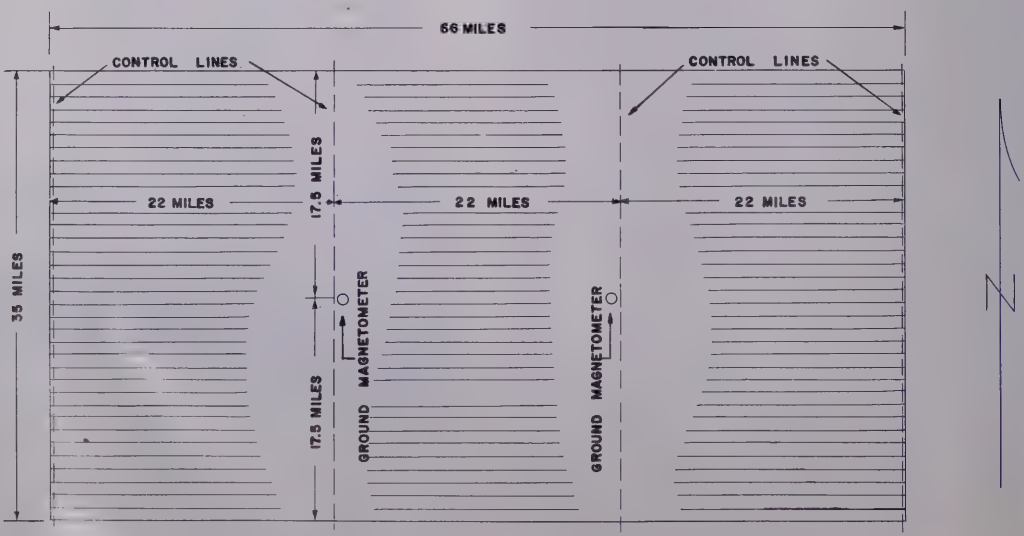

36 MILES
SINGLE FLOWN CONTROL LINE
DOUBLE FLOWN CONTROL LINE
SINGLE FLOWN CONTROL LINE
DOUBLE FLOWN CONTROL LINE
SINGLE FLOWN CONTROL LINE
N

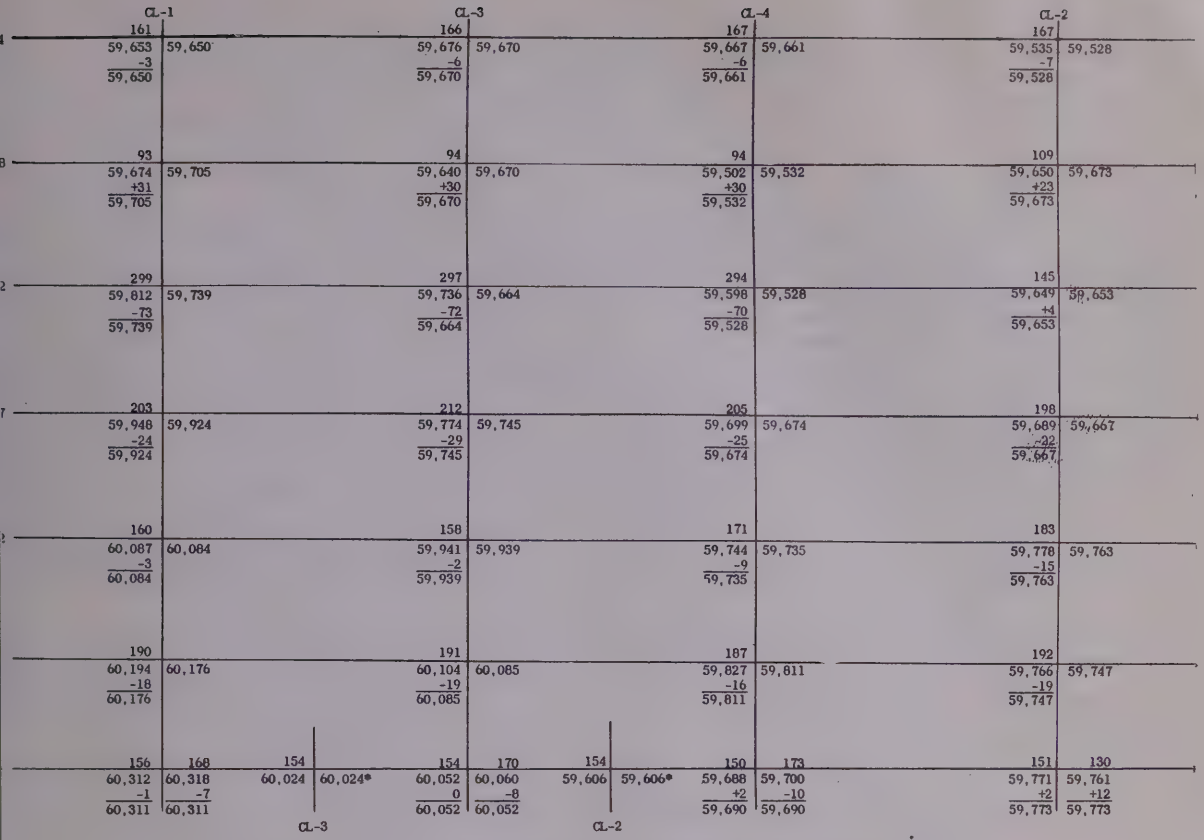
FIG. I

TRIPLE BASE-LOOP SYSTEM



TRAVERSE LINES ARE FLOWN IN EAST-WEST DIRECTION
CONTROL CROSS-TIE LINES ARE FLOWN IN NORTH-SOUTH DIRECTION

FIG. 2

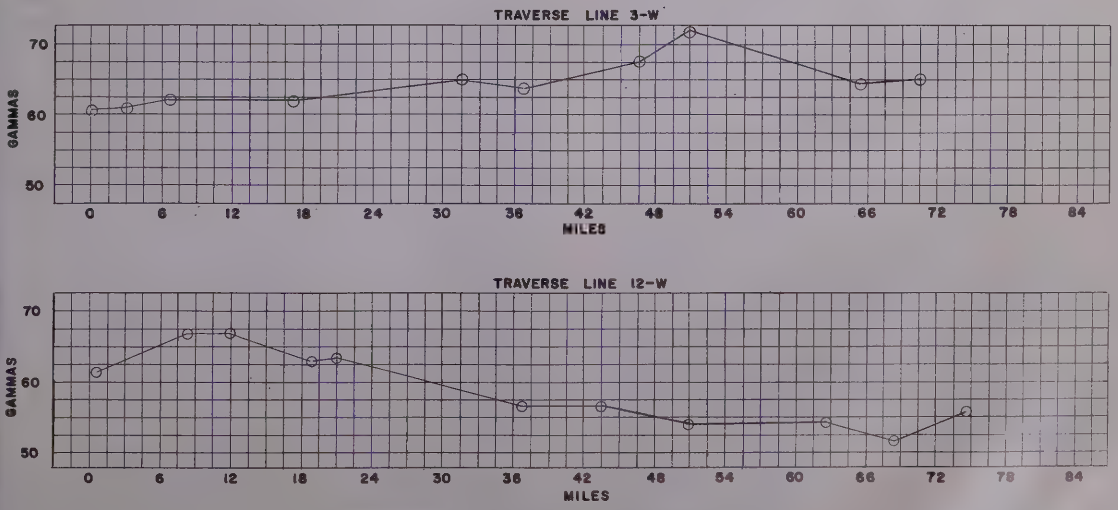


BLOCK II with Tie-in to BLOCK I

* Diurnal removed when Block I was levelled.

ts, undertaken in N.E. BC and the Territories lying
een latitudes 59° and 61° 30', a base station control
iod unique to airborne magnetometer surveys was
ited. It consists of placing two continuous recording
station magnetometers in the area being surveyed.
e base stations record the diurnal continuously on a
our basis. While the distance between these base
ons may vary, depending upon the type of diurnal anticipated, it is, in general, a distance such that the two stations will record the diurnal perturbation simultaneously within an accuracy of plus or minus 1.5 gamma, regardless of the rate of change of the diurnal.

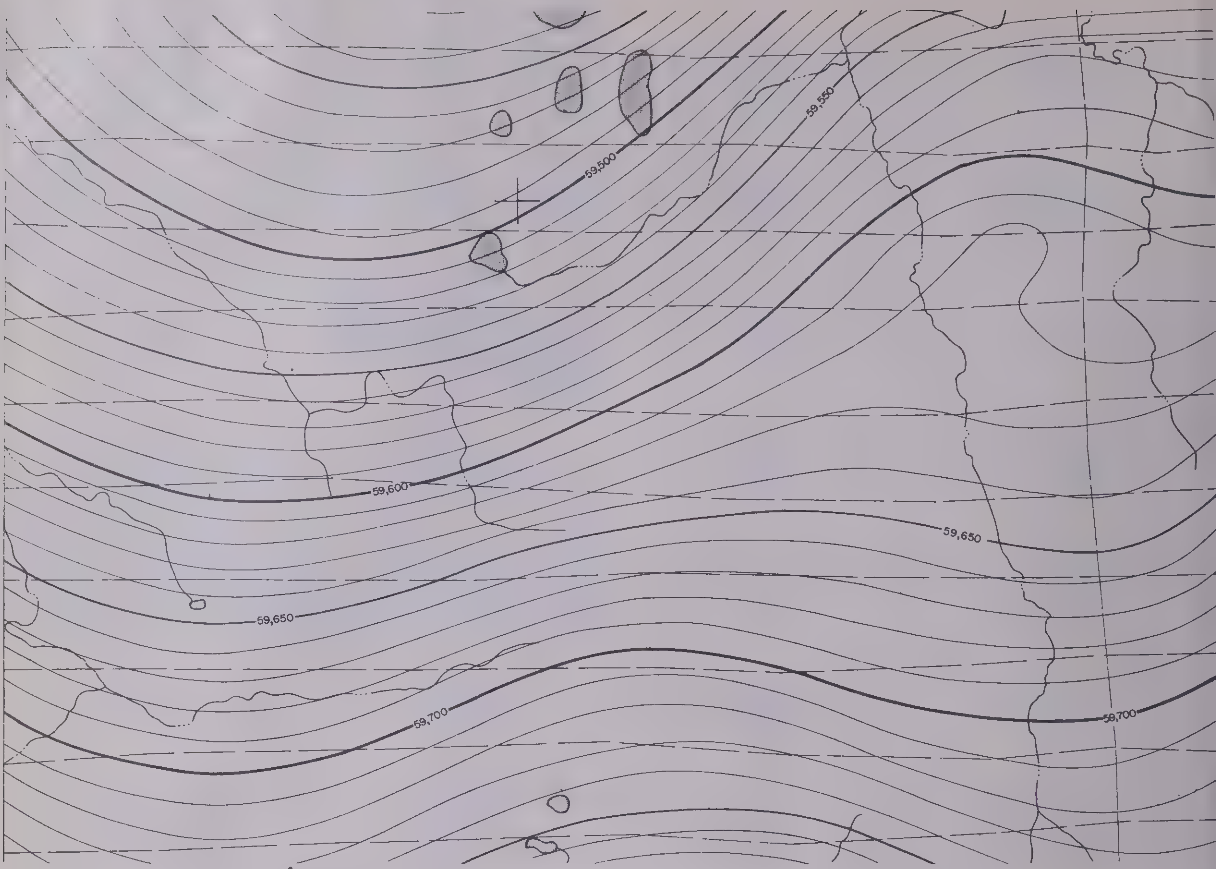
After having determined the suitable spacing of the base stations, the survey was commenced with traverse lines being flown with 1.0-mile spacing and 66 miles long in an east-west direction. For check purposes only,


TRAVERSE LINE 3-W

TRAVERSE LINE 12-W

DIURNAL FLUCTUATION AT BASE STATION DURING
SURVEY OF TRAVERSE LINES 3-W AND 12-W

FIG. 4



Sample of Isomagnetic map using absolute recorded data.

cross-tie lines, or profiles, were flown 22 miles apart and in a north-south direction, Fig. 2. Using only such data that were obtained while the base stations were operating within the specified plus or minus 1.5 gamma, it was found that direct subtractions of diurnal values could be made, giving excellent loop closures.

Fig. 3 indicates the values at the intersections of traverse and tie lines, with the recorded base station correction applied. Note, too, in Fig. 4 the magnetic variation recorded at the base station during the period when T-3W and T-12W were flown. To ensure accurate contour spacing on the final "Total Intensity" map, the original tape is replotted, with diurnal and regional removed, at final map scale to enable direct tronsfer of contour points. Fig. 5 is an example of a map compiled at 1.0 inch equals 1.0 mile; note the smoothness of contours.

Necessity of Good Control

Like a survey of any type, the aeromagnetic survey cannot be more accurate than the control used. Using data that have diurnal improperly removed, or if carelessness is allowed when transferring fiducial points and/or if base maps are poorly constructed, only a low grade survey will evolve. Interpretative work on such a survey is almost useless, particularly derivative computations. Not only would the maps be of poor quality, but incorrect and misleading conclusions can be drawn, rendering the survey worse than useless.

Good horizontal control can be obtained when using accurate navigational devices, such as Shoran, Radan or Decca, or accurate photo-mosaics can be constructed and used should photography and good map control be available. Accurate altimeter tapes are necessary, since certain fluctuations in altitude of the instrument will cause fluctuations in the earth's total intensity field at the sa
point.

One of the more important steps when compiling d
is the accurate positioning of the flight line and
fiducial points on the base map. Errors caused by t
can show up visibly on the map as "herringbone" contou
Derivative computations on this quality of map wo
also be quite unreliable.

Extreme Accuracy Needed

To what extent should the absolute accuracy be tak
Since changes in polarizations or the mineral composit
of certain iron-bearing mineral deposits, field stren
changes are in the hundreds or thousands of gamr
the change in field strength due to basement topograp
is measured in only units or at most tens of gamr
Take for example a 10-gamma diurnal pulsation on a
line during a 1.0-minute interval, which can happen,
traverse lines would now be forced to close on the
line, with the result that a second derivative contour m
would indicate a possible topographic high at this po
The distinguishing difference, on a profile trace, betw
changes in polarization and basement topography, is
slope of the curve at any point on the profile, even thou
the magnitudes of both intensities are similar. Sho
diurnal be left in the original trace, then the distingui
ing difference between the two conditions becomes masl
and more difficult to recognize.

Surveys must be made accurate to plus or minus
gamma in these northern latitudes to ensure that diur
is adequately removed and to enable the interpreter
produce accurate quantitative as well as qualitative resu

Conclusions

It is evident from the number of airborne m meter surveys that have been made to date in northern udes that periods suitable for conducting surveys are limited, due to magnetic daily variations not being ır for a sufficient length of time. It is also obvious ı the work done by the Geological Survey of Canada ıorthern Alberta, and from the survey referred to er in this paper, that one of the only accurate means controlling petroleum magnetometer surveys, where t pulsations of significant magnitude occur sporadical- is to use base stations in the survey area. Unless the commercial survey companies, and the exploration companies are prepared to conduct surveys using base stations, the usefulness of magnetics will be impaired, and interpretations will suffer. With the successful results obtained in the middle latitudes where good control was simpler, the usefulness of magnetics has been established. It would be a grave error to render magnetic surveys unsuitable, because of lack of control, particularly in the northern regions where any other types of geophysical surveys involve tremendous expenditures.

LOW-COST ARCTIC OIL

(Continued from Page 11)

In the Arctic Islands, "because of certain unique ures," the government may find it necessary to adopt modified type of reservation system," Hamilton told CPA. He listed the following possible methods:

In the Arctic Islands, we might consider permitting the original discoverer to earn the Crown reserve; and

In the Arctic Islands, or on the mainland, the government might be prepared to 'farm out' the Crown reserve: (a) to the original discoverer in the permit area for a fixed royalty—say 50 percent; (b) to the original discoverer simply to produce the oil for the Crown—the Crown to take all profits on the Crown reserve; (c) the Crown might put up the Crown reserve for cash bonus or royalty bid and give first right of waiver on the highest bid to the discovery company; and (d) we might consider a policy of putting up the entire Crown reserve in one grid or permit area in a single block or at the most a few blocks, rather than in single section pieces. This would reduce the number of operators in the pool.

"In these ways and many others that might be devised, Crown might dispose of the Crown reserve in such vay as to foster unit operation and thus assist the nomics of oil production, if it considered this was ential to any given field or pool. We intend to keep Crown reserve disposition policy flexible so that it ensitive to the needs of the industry at the time. This ibility need not cost the government any loss in enue but it would require some new thinking in ıada on the disposition of Crown reserve."

FROM OILWEEK, NOV. 20/59

BIG TASK, BIGGER REWARDS AWAIT ARCTIC OIL HUNTERS

By J. D. BATEMAN
President, Dominion Explorers Limited

A decade hence, 1959 may be recalled as an important year in the history of Canadian oil exploration. It was early in that 12-month period that private enterprise began its concerted drive to uncover the petroleum riches locked in the nation's northland. Though scientific findings are only now beginning to filter through, geologists are excited about the prospects. Much of the Arctic islands land mass is underlain by formations similar to those which produce oil in other parts of the world. Modern transportation experts are finding themselves taxed to the utmost in an attempt to keep up with demands for faster, tougher, more reliable transportation across the rugged terrain.

The year 1959 marked the first penetration of private enterprise into the Canadian Arctic islands, and this was accomplished under the banner of the petroleum industry. Early in the year, within the space of a few weeks, applications for petroleum and natural gas permits on the islands were made on an area in excess of 72 million acres, creating one of the most extensive land plays in the history of petroleum exploration.

It has long been known that parts of the Arctic islands are underlain by geological formations similar to those from which oil is produced in other parts of the world and, indeed, bituminous strata were observed there as early as 1819. During the post-war period the Geological Survey of Canada, in 1947, commenced a program of systematic reconnaissance geological mapping of the Arctic islands, and this work is still in progress.

Prior to 1959, a few preliminary publications resulting from these studies had appeared and, in subsequent months it was expected that further results of geological work in the Arctic would be published. As it seemed likely that forthcoming publications would stimulate interest in petroleum circles, the writer, acting on behalf of Dominion Explorers Limited, made application for the petroleum and natural gas rights covering more than 4,000,000 acres. It was not known that others, at the same time, were contemplating a similar action; although the Department of Northern Affairs and the Geological Survey had been receiving an increasing number of enquiries relating to petroleum prospects and the petroleum and natural gas regulations in the Arctic islands. The precipitous rush of applications for permits that took place will inevitably result in a serious endeavor to discover and produce petroleum products in the Arctic.

Accessibility and Climate

Access:

The northern group of islands in the Canadian Arctic, known as the Queen Elizabeth Islands, is accessible by aircraft at the five weather stations established by the Canadian government, namely Resolute, Mould Bay, Isachsen, Eureka, and Alert. The largest of these stati is at Resolute and is maintained by the Air Transp Command of the Royal Canadian Air Force.

For a period of two to three months during summer, ships enter Lancaster Sound from Baffin B and it is generally possible to reach most of the isla adjacent to Lancaster and Viscount Melville Soun During many years ships are able to enter Jones Sou and continue north as far as Eureka Sound. With assistance of ice breakers, access for ships to nearly but the most northwesterly islands is practicable.

Climate:

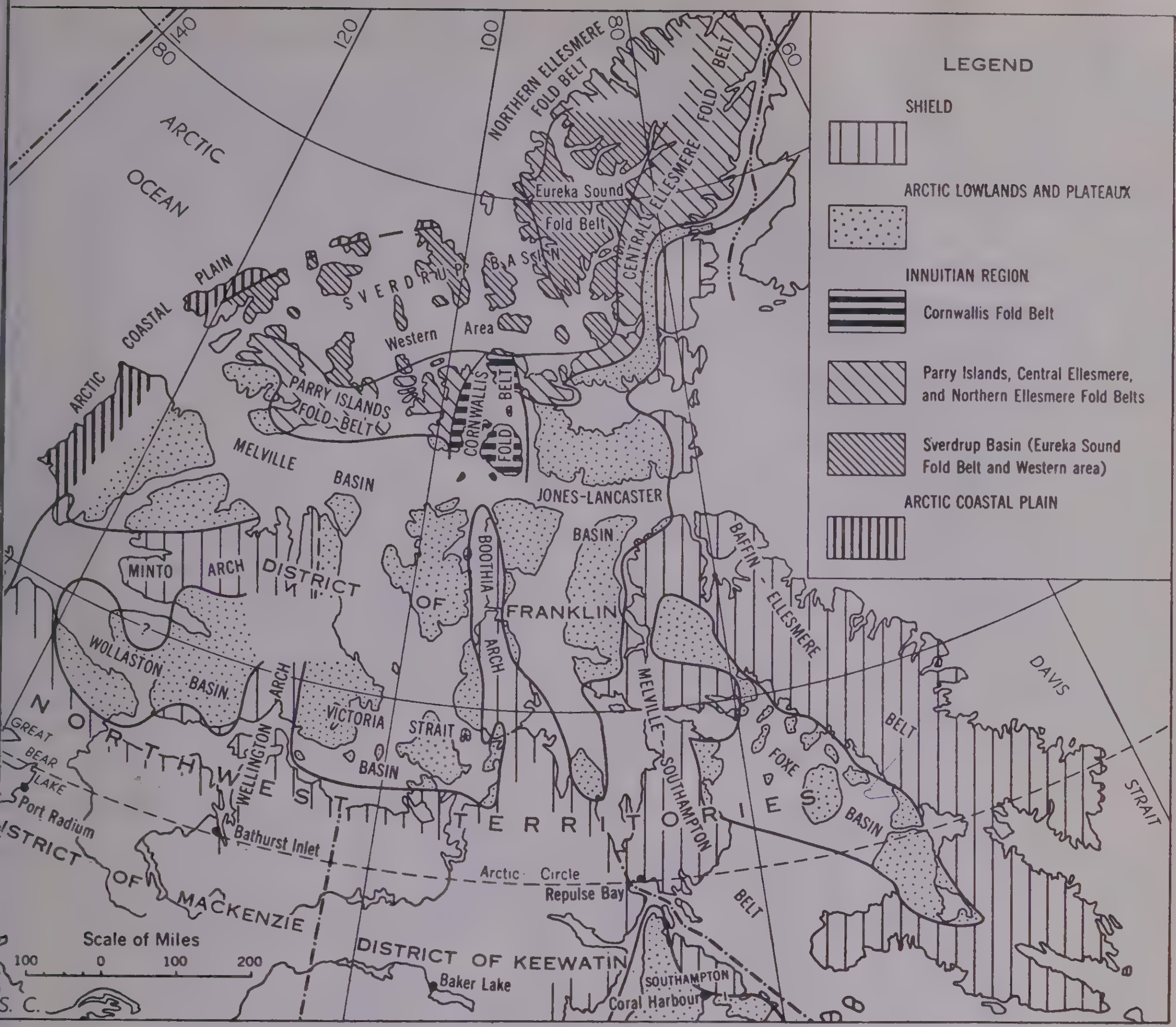
The weather in the northern Arctic is essentially maritime climate, modified by prevailing northeaste winds from the east Greenland Sea. Consequently extremes of temperature in summer and winter are as great as those experienced at lower continental l tudes in Yellowknife and Whitehorse. The summer hi reach 65 degrees and the winter minima seldom d below minus 45 degrees, comparable to temperature c ditions under which drilling rigs have operated in north Alberta.

In the central Arctic violent storms are uncomn and the average wind velocity at Resolute is slightly than that at Toronto. The climate is arid and ann precipitation throughout all but the most easterly p of the area ranges between two and eight inches. T working conditions, which may at times be severe the winter, do not preclude the possibility of conduct operations throughout most of the year.

Permafrost:

Permanently frozen ground and rock is known extend to a depth of at least 1,200 feet at Resolute is likely several hundred feet deeper. Thus, in any d ing operations, the normal precautions for drilling permanently frozen ground must be exercised.

During summer the soil thaws to a depth of appr mately six to eight inches and, in certain types of terr including soils derived from clay shales, conditions r be difficult for walking.



logic regions and subdivisions of the Arctic Archipelago. From the Geological Survey of Canada.

Until the establishment of the weather stations fol-
ing World War II there is no recorded history of native
upation of the Queen Elizabeth Islands. Several
ilies of Eskimos, aggregating about 75 persons, have
established themselves at Resolute and are said to
lmost self-sustaining. Throughout the islands, how-
, numerous stone tent rings have been observed and
mute evidence that Eskimos once hunted on the
hern islands; and the presence of whalebone on the
h shores of Bathurst Island and elsewhere is evidence
, at one time, the natives conducted whaling opera-
s north of Barrow Strait.

Numerous herds of musk-ox graze on the islands and,
e caribou are widespread, they are not as abundant
n the mainland. Wolf, white fox, Arctic hare, and
ning are common as well as polar bear. In the sea,
le, walrus, seal, and several varieties of fish are pres-
Birds include ptarmigan, geese, ducks, and many
ller species. Moss and lichens are the principal source
ood for the musk-ox and caribou and, during the
mer, short varieties of grass and several species of
l Arctic flowers flourish.

n planning the field work undertaken by Dominion Explorers, it was necessary to consider carefully all the physical and geographic conditions involved in a remote operation and, in this respect, the officers of the Geological Survey, who had pioneered geological work in the Canadian Arctic, provided much valuable advice. Economy of operations, safety of personnel, and effectiveness of results were all prime considerations.

Owing to the lack of continental glaciation in the area under investigation, outcropping rock is widespread and geological structures are well expressed at surface. Therefore, surface geological mapping was considered the most effective approach to petroleum investigations, with emphasis on the detailed measurement of stratigraphic sections, determination of facies change and reef trends, and structural interpretation.

In order to expedite the summer program the writer visited Resolute early in June. The effective field season on most of the islands is of three months duration, extending from June 15 to Sept. 15. However, in many localities, owing to the relatively light snowfall it is possible to study stratigraphic sections commencing early in May under conditions of continuous daylight and clear skies.

A three-man geological party was assembled under the leadership of Dr. A. H. McNair, professor of geology at Dartmouth College and an enthusiastic student of Arctic geology. The party proceeded to Yellowknife early in June, and was transported to Resolute (a distance of some 800 miles) by Bristol freighter aircraft, together with supplies, equipment, and provisions required for the season. At Resolute the party was met by two Piper Super Cub aircraft and, throughout the course of the season the three geologists and two pilots worked together as a unit.

The use of Piper Super Cubs for field work in the Arctic islands was pioneered by W. W. Phipps of Bradley Air Services Limited and the aircraft was successfully employed by the Geological Survey during the 1958 field season. For this purpose the planes are provided with large, oversized, underinflated tires; and with such equipment the aircraft employed by Dominion Explorers made more than 500 landings on the islands without incident. Ridge tops and flat stream beds offer the most suitable terrain for landing. This method provides an excellent flexibility of movement at a reasonable cost.

The planning of field work for 1959 was not commenced in time to lay in stores of aviation gasoline, and the requirements this year were purchased from the Royal Canadian Air Force at Resolute. During the summer aviation gasoline required for 1960 was forwarded to Resolute by ship together with certain other supplies. During the spring of 1960 it is planned to transport the gasoline to sites selected for base camps by ski-equipped DC3 aircraft.

Field Work Methods

Exceptionally clear air photography covering the areas held by Dominion Explorers was available from the government from photographs taken during 1958. Accordingly a substantial contract was let for a photogeological study and interpretation. As the results of this study would not be available for the 1959 field season, photomosaics were obtained covering that part of Bathurst Island on which it was planned to initiate field work. The mosaics were semi-controlled on scales of one mile to the inch and two miles to the inch, and were mounted on sheets of masonite of a size convenient to carry in the aircraft and use in the field. The mosaics were used for control while airborne, and for mapping on the ground.

In the fold belts on Bathurst Island many thousands of feet of strata were measured with a steel tape and, it was possible to project many of the formational contacts on the photomosaics as much as five to 10 or more miles on either side of the line of traverse.

The excellent quality of air photography, use of light aircraft in the field, and good expression of rock structure at surface were the principal factors contributing to the accurate geological mapping of a large area in a limited time.

Central Arctic Geology

The best and most up-to-date summary account of Arctic geology is to be found in the chapter on the Arctics Archipelago appearing in "Geology and Economic Minerals of Canada," Geological Survey of Canada, Ottawa, fourth edition. In recent months a number of preliminary geological maps covering most of the central and northern Arctic islands have been issued.

It is stated the Arctic Archipelago is, geologically,

Geological Survey of Canada

Major Tectonic Classification			Region		
GEOLOGICAL REGIONS			SHIELD		ARCT
SUB-REGIONS			BAFFIN-ELLESMERE BELT	FOXE BASIN with Akpatok & Southwestern Southampton Island	VICTORIA STRAIT BASIN
ERA	PERIOD	EPOCH			
CENOZOIC	QUATERNARY				
	TERTIARY		? Basalt flows, agglomerate, tuffs		
MESOZOIC	CRETACEOUS AND/OR TERTIARY				
	CRETACEOUS	UPPER			
		UPPER AND/OR LOWER			
		LOWER			
	JURASSIC AND/OR CRETACEOUS		Sandstone, sand, shale, coal		
	JURASSIC	UPPER			
		LOWER AND MIDDLE			
	TRIASSIC AND (?) JURASSIC				
	TRIASSIC	UPPER			
		MIDDLE			
		LOWER			
PALÆOZOIC	PERMIAN				
	PENNSYLVANIAN				
	PERMO-CARBONIFEROUS				
	PERMO-CARBONIFEROUS OR EARLIER				
	DEVONIAN	UPPER			
		MIDDLE			
		LOWER OR MIDDLE			
	SILURIAN AND/OR DEVONIAN				
		UNDIFFERENTIATED			
	SILURIAN	UPPER			"Atrypella beds" Dolomite, dolomitic limestone
		MIDDLE		Limestone, dolomitic limestone	
		LOWER			
	ORDOVICIAN	UPPER		Limestone, shaly limestone, calcareous shale	
		MIDDLE			Limestone
		LOWER			
	CAMBRIAN AND/OR ORDOVICIAN				
	CAMBRIAN	MIDDLE			
		LOWER			
	PRE-PENNSYLVANIAN IN PART TO POSSIBLY PRECAMBRIAN				

Table of formations of the Arctic Archipelago. From the Geological Survey of Canada. Formations shown are down to the Pre-Cambrian.

…ATEAUX	Unstable Region								Coastal Plain
	INNUITIAN REGION								ARCTIC COASTAL PLAIN
	Caledonian Orogeny	Variscan Orogeny		Variscan and Alpian Orogenies	Precambrian(?) Variscan and Alpian Orogenies	Alpian Orogeny			
						SVERDRUP BASIN			
MELVILLE BASIN	CORNWALLIS FOLD BELT	PARRY ISLANDS FOLD BELT		CENTRAL ELLESMERE FOLD BELT	NORTHERN ELLESMERE FOLD BELT	EUREKA SOUND FOLD BELT	WESTERN AREA		
									? BEAUFORT Sand, gravel, wood
				Shale, sandstone, limestone, peaty and lignitic coal, lithified wood	? Mudstone, sandstone, shale, conglomerate, lithified wood Basalt conglomerate	(Including EUREKA SOUND GROUP) Sandstone, shale, coal, carbonized wood, clay Gabbro conglomerate, coal			
						Sandstone, siltstone, shale, mudstone, coal, nonmarine	Sandstone, siltstone, shale, conglomerate with basalt fragments		
						Shale, lesser sandstone, minor shale probably bentonitic, some ironstone, marine	Ringnes Islands Shale, minor silty shale, some ironstone, marine	Graham I. Shale, minor shale probably bentonitic marine	
				? Gabbro	? Gabbro	? Gabbro Basalt flows, agglomerate Sandstone, shale, "at least in part nonmarine"	? Gabbro ? HASSEL Sandstone, siltstone, minor shale and limestone	Sand, sandstone	
						CHRISTOPHER Shale, lesser sandstone, siltstone, minor conglomerate and agglomerate marine ISACHSEN Sandstone, lesser shale, siltstone, minor coal, local agglomerate, mainly nonmarine	CHRISTOPHER Shale, some argillaceous limestone, ironstone, minor sandstone, siltstone, conglomerate marine ISACHSEN Sandstone, lesser shale, siltstone, minor conglomerate, coal, agglomerate	Prince Patrick I. LANDING LAKE Shale, lithified wood MOULD BAY Sandstone, shale, coal	
						DEER BAY & REPTILE CR. Shale, in part some sandstone, marine	DEER BAY Shale, minor sandstone, siltstone, ironstone		Sandstone, shale ?
						Sandstone, shale, marine and nonmarine Shale, marine	Cornwall Island ? Sand, sandy shale, minor coal Sandstone, sand, in part carbonaceous	WILKIE POINT Sandstone, sand, in part carbonaceous	
						(Including CAPE WITH) Varicoloured sandstone, shale, siltstone, coal in upper part marine in lower part	Sandstone, sand, coal, pebble beds		
						BLAA MOUNTAIN Marine shale, siltstone, sandstone, some limestone, calcareous siltstone	Marine sandstone and limestone ?		
				GREELY FIORD DANA BAY FEILDEN Limestone, shaly limestone, cherty limestone, minor sandstone and conglomerate		GREELY FIORD Sandstone, limestone, cherty limestone, shale, glauconitic sandstone, conglomerate	Melville & Cameron Is. Sandstone, conglomerate, shale Sandstone, glauconitic sandstone	Grinnell Pen. Limestone, sandy clay, minor sandstone, ironstone concretions	
	INTREPID BAY Sand, clay, coal, nonmarine					CANYON FIORD Sandstone, limestone, conglomerate	Sandstone, conglomerate, shale	Limestone, sandstone, conglomerate, in part nonmarine	
				GUIDE HILL Sandstone, conglomerate, minor shale and limestone	Limestone conglomerate, cherty limestone and (?) sandstone				
						Gypsum	Gypsum		
? Marine limestone and sandstone with coal		West MELVILLE ISLAND Mainly nonmarine sandstone, in part micaceous with siltstone, beds of marine calcareous sandstone and limestone and, in upper part, coal	East Siltstone, shale partly marine Sandstone, shale, coal	Sandstone, shale, coal					
	Sandstone Limestone, calcareous shale, sandstone		Shale, silty shale, calcareous sandstone, limestone Calcareous shale and limestone	Limestone, sandy limestone, sandy shale, sandstone Limestone, dolomite, calcareous shale					
			Calcareous and argillaceous sandstone	Calcareous shale, and siltstone,					
Conglomerate, sandstone, siltstone, limestone, in part nonmarine	Eastern Bathurst Island Sandstone, basal conglomerate Limestone, limestone conglomerate, dolomite, sandstone Cornwallis Island Northern DISAPPOINTMENT BAY Dolomite, sandstone, limestone conglomerate	Cornwallis Island Eastern SNOWBLIND BAY Limestone conglomerate and breccia, sandstone, siltstone, in part nonmarine		Canyon Fiord Quartzite, quartz-sericite schists, phyllite slate, chert, chert conglomerate Sandstone, sandy shale, slate Troll Fiord North Siltstone, sandstone, shale Troll Fiord South Limestone, silty limestone	Druro Range Sandstone Dolomite				
		Limestone, minor dolomite							
READ BAY & "Atrypella beds" Limestone, dolomitic limestone ALLEN BAY Dolomite, dolomitic limestone	Northern Cornwallis & Eastern Bathurst Islands CAPE PHILLIPS Graptolitic impure limestone, shale, cherty limestone Southern Cornwallis I. READ BAY including "Atrypella beds" Limestone, argillaceous limestone, shale, dolomite, sandstone, siltstone ALLEN BAY Dolomite, dolomitic limestone, limestone	IBBETT BAY Graptolitic shale and argillite	Graptolitic, argillaceous and calcareous sandstone CAPE PHILLIPS Graptolitic, calcareous and dolomitic mudstone and shale, in part silty	Western Part of Belt CAPE PHILLIPS Graptolitic calcareous shale, and argillite, in part micaceous, siltstone, sandstone Eastern Part of Belt "Atrypella beds" Limestone, argillaceous limestone, silty limestone, dolomite, cherty limestone ALLEN BAY Dolomite, limestone, dolomitic limestone					
Bache Peninsula District CORNWALLIS Limestone, gypsum, gypsiferous shale	CORNWALLIS Limestone, impure limestone, shale, gypsum, gypsiferous shale, sandstone ELEANOR R. Limestone			CORNWALLIS CAPE CALHOUN GANIOCERAS BAY CAPE BAIRD Limestone, shale, siltstone, gypsum, gypsiferous shale ELEANOR R. Limestone, dolomite	CHALLENGER Limestone, sandstone, lesser volcanic rocks				
NUNATAMI (fossils) CAPE WEBER (fossils) CAPE CLAY Limestone CASS FIORD Limestone, limestone conglomerate									
		CANROBERT Silty dolomite, edgewise conglomerate		Limestone, limestone conglomerate					
CAPE WOOD Limestone, dolomite CAPE KENT Limestone POLICE POST Limestone, minor conglomerate				Limestone, minor shale					
				(Stratigraphic relations not known) VIEW CREEK (Palæozoic) Sandstone, conglomerate, slate, phyllite, quartzite, limestone, greywacke SAIL HARBOUR Shale, slate, argillaceous limestone MOUNT DISRAELI Calcareous slate, and phyllite, limestone, argillaceous limestone CAPE RAWSON Slate, phyllite, limestone, sandstone, quartzite, chert	IMINA Subgreywacke greywacke, argillite BOURNE Lavas, lesser slates, phyllite, tuffs M'CLINTOCK Lavas, breccias, tuffs, greywacke, slate, sandstone, chert, limestone, gypsum CAPE COLUMBIA Gneisses, schists, quartzite, limestone, intruded by granite, norite, peridotite, syenite				

part of continental North America and forms a partially submerged, gently undulating plain. While the sedimentary basins in the Arctic may be coextensive with the plains region of western Canada, the Arctic area may be more properly regarded as a separate and complex basin of sedimentation. The cratonic basins, comprising a relatively high proportion of marine sedimentation, are separated by less stable fold belts and also by Precambrian arches.

The fold belts and basins expose a sedimentary section ranging from Cambrian through Devonian. In general, successively younger strata are exposed towards the northwest, and the Sverdrup basin comprising the northwesterly Queen Elizabeth Islands, is expressed by a thick Cretaceous cover overlying the Paleozoic beds. The northwestern fringe of the islands is marked by the Tertiary coastal plains.

Within the Cretaceous basin are a number of piercement domes, generally circular, but also dumbbell shaped. The domes rise above the surrounding plain with a relief of about 400 feet and, on the upper surfaces, are irregularly dissected. The domes consist principally of gypsum and anhydrite and contain early Paleozoic fauna, indicating that they have pierced the upper Paleozoic beds as well as the entire Cretaceous section. The peripheral Cretaceous strata are uptilted against the walls of the gypsum.

The accompanying table of formations, after the Geological Survey of Canada, summarizes the geological sections as determined for the various groups of islands.

Basis of Selection

At the time of application for petroleum and natural gas rights the basic elements of Arctic geology were sufficiently well known from published data that the selection of areas was a matter of broad geological preference. However, owing to insufficient detailed geological information, it was necessary to make application for areas large enough that might contain a reasonable proportion of stratigraphic and structural elements favorable to the accumulation of petroleum. With these considerations in mind, the applications by Dominion Explorers were made to provide coverage on the Cratonic basins, the fold beds, and the piercement domes, thus providing considerable diversification of lithology and structure.

The areas under application include:

► The northern portion of Prince of Wales Island in the Melville sedimentary basin, where the exposed section ranges from Silurian to Devonian in age. This area was selected as it is known to be at least in part underlain by the Allen Bay formation. This formation, which consists principally of dolomite with porous, reefoid, and bituminous strata, also outcrops on Cornwallis and Somerset Islands.

► Bathurst Island east of 100 degrees longitude, where the northerly trending structures of the Cornwallis fold belt are superimposed on the easterly trending folds of the Parry Islands fold belt. The easterly striking folds are as much as 25 miles long and 10 miles wide with the synclines somewhat broader than the intervening anticlines. A series of broad domes is formed along the Parry Islands anticlines towards the east as the axes approach the hinge line of the Cornwallis fold belt.

► Certain areas on the Ringnes Islands in the Sverdrup basin covering a group of piercement domes.

Field work in 1959 was concentrated on the south half of Bathurst Island. The results of this work are not yet assembled. No live oil seeps were observed during the course of the field work; but bituminous residues of the type remaining after loss of the volatile constituents occur in widespread distribution throughout the se mentary formations on Bathurst Island. Over most the area studied, amounting to approximately 3,000 squa miles, the Middle and Upper Devonian beds are larg restricted to the synclines, and the target for potent reservoirs lies in the Ordovician and Silurian section.

In summary, the presence of coal beds, petrolifero strata, bituminous shales, and marine beds carrying wa water fauna together with a multiplicity of structur offer prospects for the existence of reservoirs that will found to contain oil in commercial quantities.

Economics and Marketing

The question most often asked is, "If you do find in the Arctic, how are you going to get it out?" Perha the best reply to that question is that, during the pa 10 years, we had little concept of many of the develo ments in science and industry that subsequently ha taken place. We can be confident, however, that su developments will take place at an accelerating rate du ing the next 10 years.

For example, submarine atomic tankers on the drawi boards today will become a reality in about six yea from now. The development of plastic pipelines th can be draped from island to island is not a wild drea and with modern ice breakers many parts of the islan are now accessible to conventional surface tankers.

The distance from Resolute to the United Kingdo and adjacent parts of Europe is considerably less tha the present tanker haul from Venezuela to Europe.

The principal justification for exploring for oil the Arctic today is the prospect that large reservoirs w be found, making it possible to produce oil at surfa at a cost per barrel less than that prevailing througho North America today.

THE AUTHOR

J. D. Bateman, in addition to being president Dominion Explorers Limited, is also president and direct of Sarcee Petroleums Limited, Lake St. Clair Gasfield Limited; chairman of th Bolivex Corporation, an vice-president and directo of a number of Canadia mining companies.

A native of Ontario, D Bateman received a B-A degree from Queen's University in 1936 and a Ph.D. i geology from Yale University in 1939.

Following this Dr. Bateman worked for a number of mining interests in Ontari and served as assistant geologist, Geological Survey o Canada from 1940 to 1942, and as associate geologis in 1943 and 1944. He served as chief geologist fo Giant Yellowknife Gold Mines Limited 1945-1950, an as vice-president and chief geologist for Ventures Limited 1950-1958, following which he established a practice as a consulting geologist in Toronto.

Dr. Bateman is a member of the Arctic Institut of North America, the Geological Association of Canada, the American Institute of Mining and Metallurgica Engineers, Society of Economic Geologists and the Canadian Institute of Mining and Metallurgy. He wa awarded the Barlow Memorial Medal by the CIMM i 1934.

M OILWEEK, NOV. 27/59

IMPORTANCE OF AIRCRAFT IN NORTH INCREASING

By NEIL ARMSTRONG
Spartan Air Services Limited

The vital role played by aircraft in the xploration of the far north is steadily being xpanded and increasing use is being made f specialized aircraft for special purposes. n the field of airborne geophysics, for in-tance, aircraft used are principally of the ight twin type, although the heavier DC3 have been used occasionally. Airborne survey units are in heavy demand for magnetometer work.

Recently a United States Strategic Air Command -135 Stratotanker visited Calgary. This aircraft is mally used to refuel intercontinental bombers flying usands of miles at high altitudes. The amount of l the Stratotanker can carry for refueling purposes significant. Also significant is the amount of fuel burns itself, being some 6,000 to 10,000 pounds per ur depending on the altitude and Mach number at ich it is flown.

Based on a 6.5 pound gallon, this means that for tain jet contrails seen in the clear morning sky, 1,000 more gallons per hour of consumed fuel are being hausted to atmosphere.

Recently, at Circle Alaska, I paid 90 cents per U.S. llon for aviation fuel.

The foregoing are cases taken in their extreme. They , however, serve to illustrate to a degree fuel consump-n and fuel prices that exist today in the fast developing iation industry.

So much for the contribution aviation makes in the el consumption field. What does it do to assist finding and exploiting the fuel it requires?

Fixed and Rotary Wing Aircraft

Current aviation has two classifications. First in mbers is the conventional fixed wing aircraft. Gaining popularity and use is the rotary wing machine more mmonly known as the helicopter.

Under the fixed wing classification, aircraft that have en, and are, of service to one or more facets of the l industry are as follows:

Four-Engine aircraft such as the Douglas DC4 and e Boeing B17.

Heavy Twin-Engine machines like the popular Douglas DC3, the Bristol Freighter, Convair, Super Ventura, Lockheed Lodestar, Lockheed Hudson, Lockheed P38, Curtiss C46, and de Havilland Mosquito 35.

Light Twin-Engine aircraft comprised of the Avro Anson, Beechcraft 18, the Aero Commander, Cessna 310, de Havilland Dove, and the Piper Apache.

Single-Engine equipment consisting of the de Havilland Otter, de Havilland Beaver, Norseman, Helio Courier, the Cessna 180 and 182 and, last but not least, the Piper Super Cub.

Under the rotary wig classification equipment used consists of the Sikorsky S55 and S58, the large twin rotor Vertol, plus the Bell 47 D1, G1, G2, and J models.

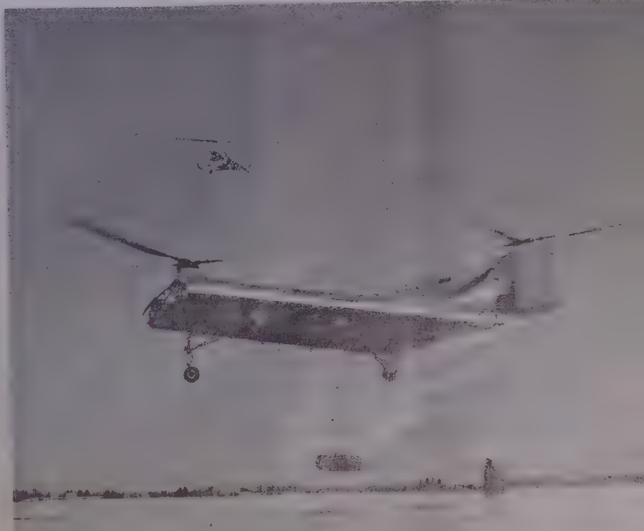
Very little of the equipment listed above has universal application throughout the industry. Rather, certain aircraft excel in certain phases of the exploration and transportation picture.

Geophysics

In the field of airborne geophysics the aircraft used are principally of the light twin type such as the Avro Anson, Cessna 310, and Piper Apache. Although the heavier DC3 has been used as well as the light single-engine Cessna 182.

During World War II the magnetometer became airborne and was used principally in submarine detection. Suitably modified after the war and installed in the foregoing aircraft it joined in the geophysical search for oil.

Two magnetometers are at present being utilized. These are the Gulf Magnetometer used since 1946 and the more recently developed Nuclear Precession Magnetometer built by Varian. The latter, an absolute reading type of magnetometer, is equipped to provide data directly in punched tape form. This can then be programmed on a computer thus eliminating transfer and computation of data by hand and thereby speeding up final map compilation.



A Vertol 42 Helicopter, capable of slinging loads of over 4,000 pounds through short distances, hauls fuel while a Bell 47 D1 flies overhead.

Helicopters frequently supply drilling rigs in isolated or inaccessible areas with fuel, equipment, parts and provisions. Above is a Spartan helicopter at a drilling site.

Airborne magnetometer surveys allow for fast coverage of large areas at relatively low cost per square mile. Regional information can quickly be made available covering remote areas of interest without being faced with the normal problems encountered when surveying roadless areas and rough terrain.

Shoran Work

Other airborne equipment used from time to time are the Airborne Profile Recorder and Shoran equipment. The former is a rapid electronic method of obtaining vertical control. Shoran, on the other hand, is used to obtain horizontal control. Airborne, these instruments offer a quick means of obtaining mapping control over difficult terrain in remote areas. The aircraft most commonly employed to transport this equipment is the Douglas Super DC3.

Geophysical surveys on the ground are also often times supported from the air. Heavier twin-engine equipment is employed to transport men, equipment and materials over the long distances and tough terrain existing between rail or water heads and well prepared airfields near the areas of interest. The single-engine aircraft then come into their own and serve to continue this airlift from the well prepared fields to remote airstrips or lakes at, or close to, the base camps. From here the helicopter takes over.

As a note of interest, this past winter a large twin-engine Bristol Freighter was employed near Aklavik to move helicopter gas from the nearest source of supply to the very lake on which the summer's base camp was to be established. Wheel equipped, it was preceded by a
de Havilland Beaver equipped with wheel-skis and a
loaded with gas. The Beaver landed on the snow
ice covered lake. The pilot checked landing conditi
and marked out a landing path. The Bristol then p
ceeded to land on the frozen surface and unload a seaso
supply of gas.

Gravity Surveys

Gravity surveys have been conducted employing he
copters to good advantage. Photographs have been
tained of the area under scrutiny. Mosaics are ma
and a survey programmed. Using the aerial photos ma
horizontal control and barometers for vertical control
pilot and gravity meter operator can cover many stati
during the course of a normal day. The rapidity w
which the operator can traverse the area and take
readings allows for added accuracy when computing
sulting barometric data. This assures better vertical c
trol. The Bell 47 G1 or G2, capable of carrying a pil
and one or two men, is most commonly used on this type
operation.

Drilling equipment efficiency seems to vary almo
directly with weight. In general the heavier the equi
ment the faster and deeper it will dig. For this reas
the larger Sikorsky S58 and Vertol 44 show promise
this type of operation. Capable of slinging two tons ov
short hauls, they allow for large drills and what may
a more efficient operation.

The smaller Bell helicopter also may have a suppor
ing role in this work. Often times it is used to transpo
the surveyor, lay geophones or move other light equi
ment. This machine's usefulness will increase too
equipment becomes transistorized and new techniqu
are developed.

Geology

Aircraft, too, support the geologist in his activiti
much along the same lines as it does the geophysicis
Equipment has to be moved by heavier aircraft to ai
fields in the vicinity. The lighter single-engine machi
then takes over to base camp and the helicopter assist
in the final survey.

Using aerial photographs the geologist, working ou
of a base camp, can be quickly transported to the outcro
of interest. Landings can be carried out on sandbar
clearings in the bush, on mountain ledges, and on favo
able mountain peaks. Eliminated to a considerable degre
are the pack train, the long slow canoe trip and, to
great degree, the slower foot-slogging type of traverse
In the evening he returns to a well supplied cook ten
his office tent and in most cases to communication wit
the outside world. Added, too, to the advantages alread
indicated, is the discovery through statistics accumulate
that this new form of transportation is more economic
by ratios of four to one or higher. For one thing
allows the geologist considerably more time per day
practice the profession for which he is trained. Then
too, this over-all picture is further enhanced by tim
saved and the more competitive position thereby gained

In the Arctic Islands this year Piper Super Cubs, too
were used to good advantage on geological work
Equipped with 35" x 15" Lockheed Electra tires and
inflated to four pounds pressure to withstand unprepared
strip conditions, this light aircraft carried a pilot and
geologist over many miles.

Aerial Photography

Aerial photography also finds its place in the exploration program.

This year de Havilland Mosquito 35's, Boeing B17's
and Lockheed P38's, Wild camera equipped, were busy
photographing the Arctic Islands from high level. Photo

s taken from 31,680 feet give a resulting scale of uals 5,280'. At this height many square miles are ed by one picture. Taken with 60 percent for- overlap the resulting photos can be used stereo- ally for photo geological, planimetric or contour ing purposes. Because of the remoteness of the nd the current interest in its petroleum possibilities, photos will, in all probability, be in considerable nd and be put to many uses.

other areas photography is carried out to assist e access problems always prevalent in the more ed remote districts. A favorite scale for this type rk is 1" equals 2,640' taken at 15,840 feet above round. This type of picture is principally taken Wild camera equipment mounted in such aircraft Cessna 310, Beechcraft 18, or the Lockheed Hud-

or more detailed examination, 1" equals 1,320' or uals 1,000 photographs may be used. Because of umber of pictures involved (four times that when at twice the height) these pictures are not as exten- used for photo geological studies as are the smaller photos previously discussed. This larger scale is, ver, a favorite when doing detailed work. Accurate ing to a closer contour interval is also permitted. camera equipment is again used and since flying tions in this case are 7,920 feet and 6,000 feet above ground respectively such aircraft as the Avro Anson he Piper Apache are often used.

s already mentioned the Wild camera is principally in all this work. Swiss made and retailing at ap- mately $18,000, it represents the latest in airborne graphic equipment. A high resolution camera, it s for clear pictures of excellent quality. Pictures by this camera when examined in 3-D on the o-plotting machines can be used for many purposes. o geological studies, planimetric mapping, topo- hic mapping, road location work and gravel searches, a few of the uses the oil industry find for this ex- tion tool.

lotting equipment used in these studies are usually elsh plotter or Nistri photo-mapper. Finely machined optically perfected this equipment is able to extract aximum of information and value from the photo- hs at hand.

Drilling

he aircraft also has a place in the drilling program. n a rough strip near the rig location may accommodate twin or single-engine equipment. These transport lies, parts, men and materials to the site. Sometimes elicopter may be retained at the location. This is cially true over freeze-up or break-up. It may be to bring in a diamond bit, a core barrel, or other pment, small in terms of weight but of considerable ificance when the necessity for their use arises. Also ffers a fast means of transportation when roads are and quick access to medical facilities should this be ired. In this respect its presence is a morale builder, gnificant aspect in itself.

The use of aircraft by the petroleum industry has nded to a point where many companies have created r own aviation departments. Aircraft which may be d in these departments are as follows: The Douglas 3, Convair, Super Ventura, Lockheed Lodestar, de illand Dove, Piper Apache, Cessna 310, Super lgeon, and Aero Commander. In most cases these used for executive travel. Other aircraft used may he de Havilland Otter, de Havilland Beaver, and the sna 180. These latter machines have the added ad- tage that they can be float equipped in summer, or ski equipped in winter, thus bringing geological and geophysical base camps plus wellsites to within a few hours of the office desk.

Certain companies sometimes prefer to rent the services of charter operators having bases from Lethbridge in the south to Dawson City and Aklavik in the north. Survey aircraft, on the other hand, are usually contracted from companies specializing in this type of operation. Helicopters, too, are usually leased for given periods from operators across Canada. A specialized piece of equipment requiring special maintenance, with each machine in the field having its own engineer, they operate from permanent bases located from Vancouver Island in the west to Newfoundland in the east.

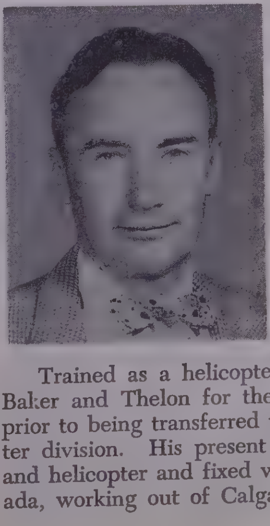
The recent advance in electronics, the simplification of equipment, the development of portable drilling rigs, the introduction of turbine engines, and the development of new techniques all serve to increase the stature of aviation in the petroleum picture.

To illustrate aircraft activity in the field of northern oil exploration I am reminded of a day in July, 1958, when flying a float equipped Cessna 180, I landed at Palmer Lake just north of the Peel River in the Yukon. It's a small lake and compares in size to Chestermere Lake east of Calgary. But in that particular area Palmer Lake represents a lot of water. (Any remaining water in the area seems to be in the few inches or feet of muskeg existing above the permafrost.) Already on the ground and preceding me by about 10 minutes was an Associated Bell helicopter. Shortly after I landed an oil company Beaver came in. This was followed by a Spartan Bell helicopter. In a matter of minutes a Connelly-Dawson Beaver landed to be closely followed by a Klondike Bell helicopter. Six aircraft in less than 30 minutes all employed by oil companies in an area normally only visited by the occasional native.

Since then oil has been discovered on the Eagle Plains and land has been taken up in the Arctic Islands. Operations are being conducted further and further from established lines of transportation and communication. This intensifies the role of the flying machine in the petroleum industry and serves to indicate that aviation will hold an accelerated position in the search for oil throughout the years ahead.

THE AUTHOR

A native of Alvinston, Ontario, Neil Armstrong served with the Royal Canadian Mounted Police in western Canada prior to joining the RCAF as a pilot during the war.



He graduated with a B.A. Sc. in mining geology from the University of Toronto in 1949, and worked with Eldorado Mining and Refining Limited, The International Nickel Company of Canada Limited and Hudson's Bay Oil and Gas Limited. He joined Spartan Air Services Limited in Ottawa in January, 1954.

Trained as a helicopter pilot he flew on Exploration Baker and Thelon for the Geological Survey of Canada prior to being transferred to Spartan's electro-magnetometer division. His present position is co-ordinating sales, and helicopter and fixed wing operations in western Canada, working out of Calgary.

FROM OILWEEK, DEC. 11/59

DEVELOPMENT OF NORTH HAMPERED BY MUSKEGS

By J. G. THOMSON
Imperial Oil, Calgary

Development of northern areas depends a great deal on the solution of problems of access. Terrain conditions rather than extreme distances are the main considerations that make the normal means of land travel unsuccessful in the north.

One of the most important terrain obstacles is muskeg, access over which usually requires more than conventional practice provides.

Before undertaking a transportation job over muskeg, complete recognition and classification of the terrain must be undertaken and the most useful vehicles have to be chosen.

Conclusion

The development of northern Canada has been, and continues to be, hampered by difficulty of access. This applies, as noted in the Gordon report, to all industries which are attempting to expand their operations into this region.

Fixed-wing aircraft, vertical take-off aircraft, helicopters and air-cushion vehicles can all contribute to northern access. None of them represents a complete solution. Airfields can seldom be built adjacent to a development site. Large helicopters are extremely expensive to buy and operate, are short ranged, and require very extensive emergency facilities. The air-cushion vehicles must have a trail cleared for them and therefore have almost the same ground requirements as wheeled vehicles. In most cases these forms of transportation will only move the marshalling area for surface vehicles away from a highway. Only rarely will it be possible to eliminate the requirements for surface transportation entirely. Exploitation of the north cannot and will not wait for the development of complex transportation equipment. This is particularly true when it is obvious that these developments will raise costs.

Roads Not Solution

All-weather highways and a railroad to the Arctic Ocean will not in themselves solve the transportation problems of the north. Such access routes will allow conventional surface transportation equipment to approach but not reach most development or exploration sites. The addition of secondary and tertiary road systems will not provide a total answer either. Desirable, helpful and essential though such a road grid may be, nevertheless, at some point in most northern development projects it will be necessary to travel overland.

Terrain conditions rather than the extreme distances which can be encountered are the main reasons that normal means of land travel are unsuccessful in the north. The more important of the terrain obstacles are mountains, forests, swamps, muskegs, permafrost, snow, boulder fields, gumbo, rivers and lakes. Certain of these obstacles can be neutralized by common road construction practices. Some others, for example muskeg, do not usually yield to conver
tional practice.

The latter type of obstacle is usually first attacke
conventional means at great cost and to little avail. La
serious thought and then research go into defining
problem and determining a solution. This has been
case with muskeg which is probably the most impor
single deterrent to northern development. One fa
has eased the impact of muskeg on northern operati
it is easily traversed for a few months in winter.

Two quite different types of muskeg access are c
monly required. For exploration purposes it is usua
cover large areas on a close grid. This phase of
project requires only a few passes of relatively light eq
ment on each trail. Since the number of miles of
involved is large the cost per mile must be kept sma
the project is to be economically feasible.

The advantage of vehicles which can operate
trails which have been cleared of trees but other
unprepared is obvious. Even greater economic ad
tages are available through seeking routes which do
need to be cleared. A common source of such ro
are those muskegs which are barren of trees.

Delayed Until Winter

The second type of access over muskeg is that requ
to move heavy drilling, refining or manufacturing eq
ment to an established resource. To date such m
have been delayed until the winter season or else rou
about routes have been built to avoid muskeg. Wi
trail costs are high and repetitive if they are to be
for more than one season. Long, high ground routes
also expensive to build and require extensive mainten
in the spring and fall. Also the grades usually foun
these routes cannot be negotiated by unaided truck
winter. Here again, an all muskeg route could show
economic advantage.

Before undertaking a transportation job ov
muskeg one must be sure that the problem is unde
stood. The first requirement for understanding
to define the material which it is proposed to travers

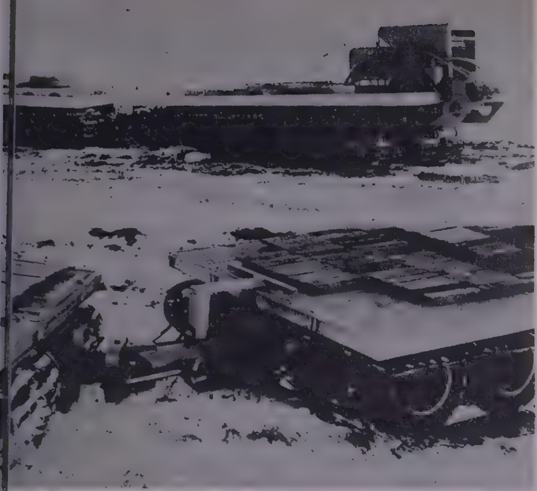


FIGURE 1

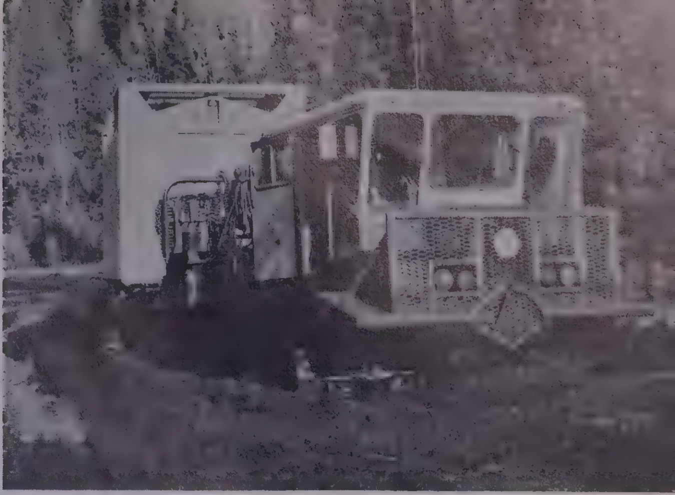


FIGURE 2

efinitions and classifications of muskeg have been ıblished by N. W. Radforth. (Ref. 1, 2, 3, 4). xperience and field testing (Ref. 5, 6, 7) have shown ıese classifications to be reliable and applicable to ehicle utilization in muskeg.

A brief outline of the Radforth classifications will onstrate the amount of factual information which been gathered on muskeg. The classifications are cisely stated conclusions drawn from masses of field a and are presented and justified in the references d above.

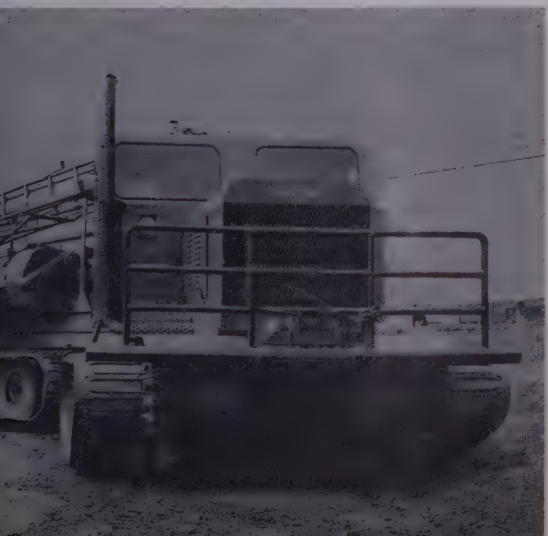
Nine Classes

The Radforth system divides the muskeg surface cover- into nine pure classes. These classes are based on ure and degree of woodiness of the living layer. cies are not involved in the classification and therefore system can be applied without a knowledge of the any on which it is based. One, two, or three-letter nbols are used to name a muskeg type. A letter symbol ıssigned for each coverage class which accounts for east 25 percent of the muskeg surface under observa- .

The basic system has been extended to provide the ntification of muskeg types from aerial photographs en at various heights. Texture and groundform shown the photographs are the basis of this interpretation. is technique is very useful in preliminary route selection permanent roads or for vehicle trails over undisturbed skeg.

Subsurface constitution and topographic features are used by Radforth to classify muskeg. In broad terms, the first of these indicates the range of bearing and shearing strengths to be expected. The second indicates in a general way the amount of pitching, deviation and speed to be expected on the route.

FIGURE 3



Using this classification as a muskeg identification datum, quantitative vehicle tests have been conducted to determine:

- ► The performance to be expected in muskeg.
- ► The feasibility of predicting vehicle performance from muskeg classification.

These tests and later qualitative tests have shown that vehicle performance can be predicted from muskeg classification data. They have also shown that tracked vehicles operating in type FI (mosses and grasses only) muskeg can produce much greater tractive effort than wheeled vehicles operating on dry concrete. In addition, a great deal of directly applicable design data has been produced.

Success the Proof

The final proof of the validity of all research and development activities lies in the successful application of the defined principles to a practical problem. This has also been accomplished. Vehicles such as the eight-ton Centipede, Fig 1, the 20-ton Imperial Musk-Ox, Fig. 2, and the 10-ton Spalding Drill Transporter, Fig. 3, are designed in part from criteria determined in quantitative field tests. Mobility, steering, and ride characteristics of these machines and payload capacity are very good. Additional designs based on test data are currently under construction. Further improvements are anticipated based on the performance evaluation of these advanced vehicles.

The present position is then:

1. Muskeg can be recognized and classified. From the classification an estimate of the performance of a given machine can be made. These estimates are available as a regular commercial service on a nationwide basis.

2. Vehicles are available which can carry useful payloads across, say, 90 percent of all muskeg at quite high utilization rates.

It remains to be shown whether or not tracked vehicles operating in muskeg are economically competitive with wheeled vehicles operating on a "high ground" bush road. An example may best illustrate this.

Example Detailed

Consider the hypothetical transportation problem shown in Fig. 4. Points A and B may both be reached by conventional wheeled vehicles operating on public roads. It is assumed that the cost of transportation to each point is approximately equal. Point C is the objective. The route A-C over types FI, EFI, DFI, A1 and BHI muskeg, is 15 miles long. Route B-C which avoids all muskeg is a clay trail with the normal complement of hills, sidehills and trees and is also 15 miles long. Assume 1,000 tons are to be moved.

For route A-C tracked vehicles must be used. The following costs will apply:

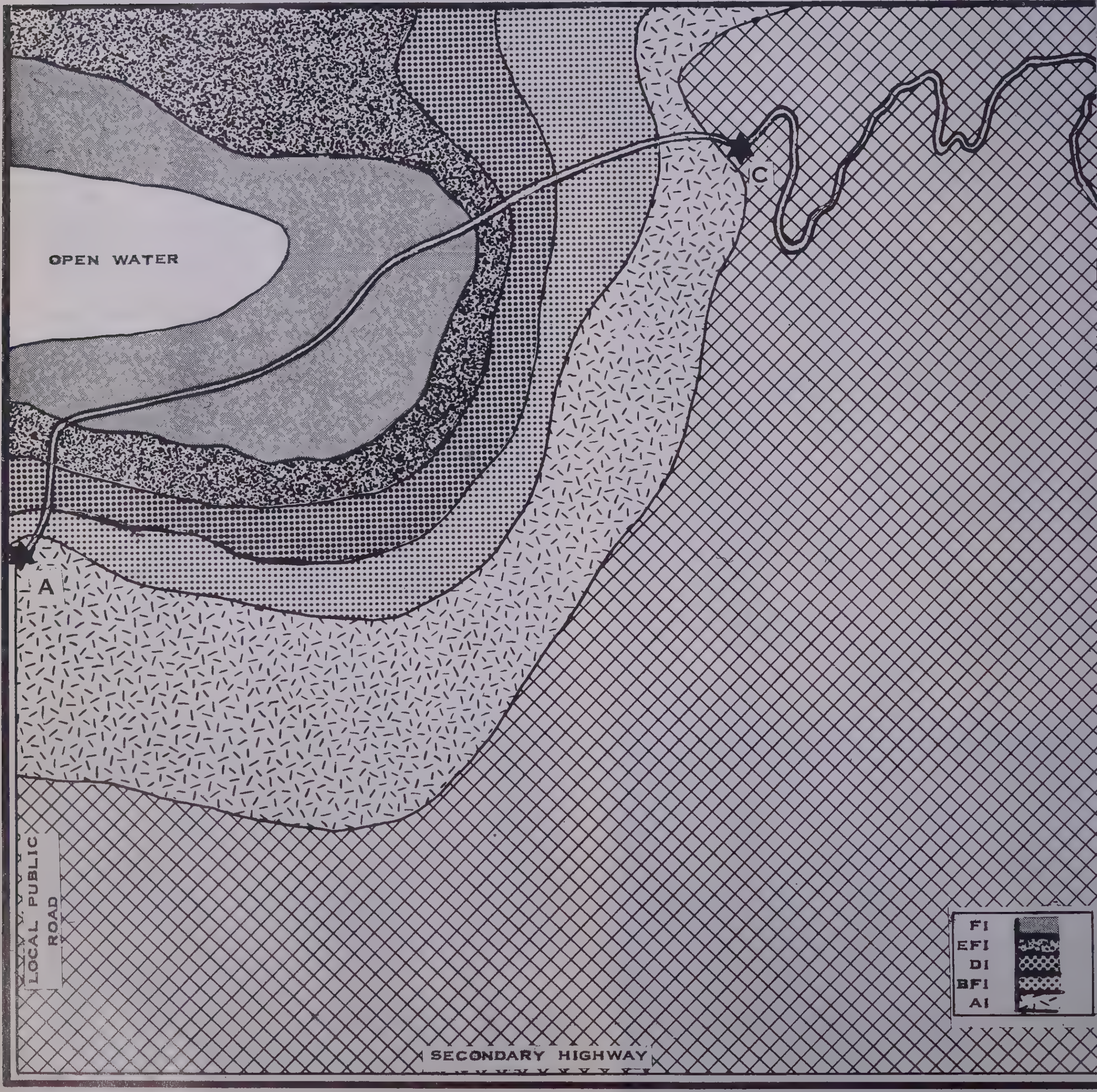
1. Route preparation:	
(a) Types FI, EFI, DFI muskeg	0
(b) Type AI 3 miles at 600/mile	1,800.00
(c) Type BHI 2.5 miles at 300/mile	750.00
II. Vehicle charge at 10 percent of cost-month:	
(a) Monthly rental/machine 5,000	
(b) Payload 10 tons/machine	
(c) Therefore No. trips 100	
Total mileage 3,000	
Average speeed 6 mph	
Total operating time 500 hr	
At 3 trips/day = 20 hr	
Total = 25 days,	
Allow 37 days for breakdown, servicing, etc.	6,25
III. Crew charges 6 man-months	3,00
Total cost	11,80
or 79c per ton mile	

For route B-C wheeled vehicles will be used bu bush road must be built.

$1,000/mile	15,00
II. Hauling charges at 20¢/ton mile	3,00
III. Crew charges—included in II above	——
Total cost	18,00
or 1.20 per ton mile	

Obviously then, the tracked vehicles are much chea

FIGURE 4



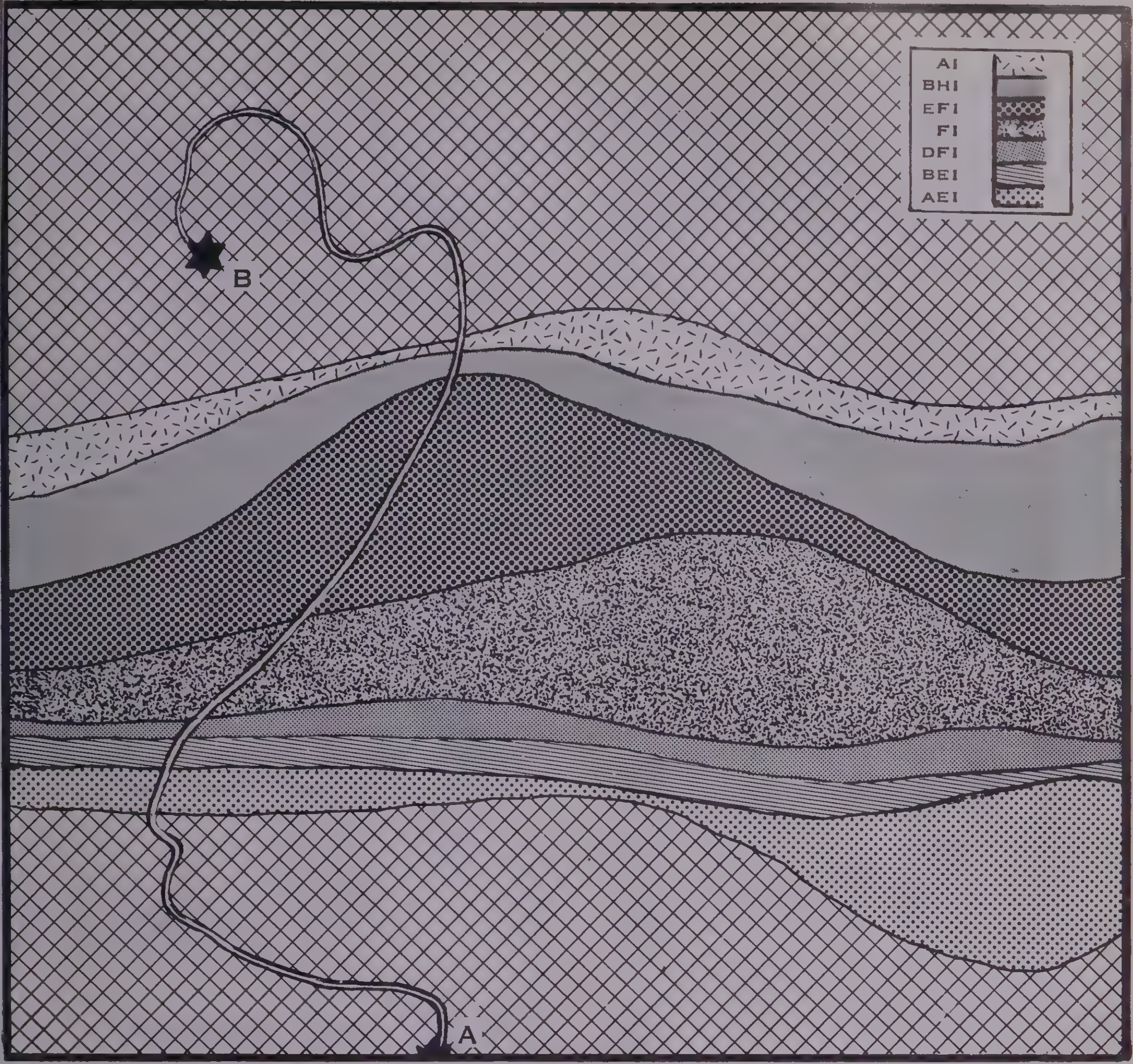


FIGURE 5

the wheeled vehicles in cases such as the one yzed. Note that no reasonable adjustment of the cost figures shown will change this result. Even if lready lower-than-average road building costs are cut lf, or the already very generous breakdown allowance ner increased, the tracked vehicles still have the ntage. In practice, route B-C might often be exed to be 25 percent to 100 percent longer than route . In that case the advantage of tracked vehicles is greater.

Note the effect of increasing the route length by a or of 10. The cost rates remain constant but the s in dollars separate. Tracked vehicles will cost 3,000 while wheeled vehicles will cost $180,000. The erence between these two figures will more than pay one 10-ton tracked vehicle and the maintenance reed to keep it in the field for one year. An allkeg route of 150 miles is of course an unlikely occure. It is not impossible.

Road Cost Dips

One other variable should be examined. If the tonnage e hauled is increased the road cost in dollars per mile decreases. Assume the given example refers wildcat. Then about 60 percent of the tonnage will ransported back from the lease. Total costs will then 17,350 (58c a ton/mi) by tracked vehicles and $21,000 a ton/mi) by wheeled vehicles. In other words, the advantage of the tracked vehicles has been decreased to 59 percent of the earlier value. This result may be generalized. As the number of tons increases road costs can more easily be borne. At some point, dependent on tonnage and equipment, it will be cheaper to build a road and use wheeled vehicles.

A third possibility for reaching point C exists. A winter trail suitable for truck use could be prepared along route A-C. In that case the charges would be:

I. Route Costs	
5 miles (AI, BHI) at 1,000/mi	5,000
5 miles (DFI, EFI) at 500/mi	2,500
5 miles (FI) at 100/mi	500
II. Hauling Charges at 20c/ton mi	3,000
Total Cost	11,000
or 75c a ton/mile	

This very small saving over the cost of a tracked vehicle operation in summer will not be justified if there is any urgency to the project. Further, falling or drifting snow could easily raise the noted costs by 25 percent to 50 percent if the operation is carried out over a period of weeks. Since the route will be fairly level towing charges need not be anticipated.

As in the first part of this example an increase in the number of ton/miles accomplished affects the results. If 60 percent of the material is back-hauled the total cost becomes $12,800 (43c a ton/mi). Against this substantial saving must be balanced:

1. The possibility that the equipment cannot be retrieved before spring "break-up." In this case the "laid-down" rental on the rig for 9-10 months must be added to the transportation charges. The route costs for rebuilding the route the following winter will add $1,500 to $2,500.

2. To ensure completion of a wildcat before "break-up" a larger rig than necessary is often used. The extra rig rental should be added to the transportation costs. Also, the transportation charges should be calculated on the basis of, say, 1,000 tons on the winter road and 700 tons on the summer trail to account for the oversized rig.

Profitable Use Possible

There is no doubt that the capability to use muskeg at a profit exists. It has not existed for long, however, and there are still pitfalls. The greatest of these is lack of understanding of the effect of a mixed route on either form of transportation. A second example will help clarify this situation.

Consider Figure 5. The hypothetical route shown is five miles of muskeg and 10 miles of mineral soil. Again, assume 1,000 tons are to be transported.

I. Route Costs:		
(a) 10 miles of mineral soil		
i suitable for wheels	10,000	
ii. suitable for tracks		6,000
(b) 5 miles of muskeg (mixed)		
i. suitable for wheels	25,000	
ii. suitable for tracks		3,000
II. Vehicle Costs		
i. Trucks	3,000	
ii. Tracked vehicles		6,250
iii. Crew charges		3,000

Total cost wheels ....$38,000 or 2.57 a ton/mile

Total cost tracks—$18,250 or 1.22 a ton/mile

It is seen, then, that substituting 10 miles of mineral soil for muskeg raises the cost of tracked vehicle operation by 55 percent. The substitution of five miles of muskeg for mineral soil raises the cost of wheeled vehicle operation by 114 percent. From this it may be concluded either that:

► Tracked vehicles are more adaptable to a role which can be handled by wheeled vehicles than are wheeled vehicles to the tracked vehicle role, or,

► If public roads do not exist only tracked vehicles should be used along with minimum trails.

Again, a winter operation could be substituted. Using the same route the charges will be:

I. Route Costs:		
(a) 10 miles of mineral soil		
(i) suitable for wheels	10,000	
(ii) suitable for tracks		6,000
(b) 5 miles of muskeg (mixed)		
(i) suitable for wheels	2,500	
(ii) suitable for tracks		1,500
II. Vehicle Costs:		
(i) Trucks	3,000	
(ii) Tracked vehicles		6,250
(iii) Crew charges		3,000

Total cost wheels, $15,500 or $1.03 a ton/mile

Total cost tracks, $16,750 or $1.12 a ton/mile

As in the previous example, a saving is available f
wheels in winter over tracks in summer. These s
savings in winter time must be balanced against the s
season available in all but extreme northern latitu
and against possible reduction of crew effectiveness
low temperatures.

The knowledge and equipment to develop Cana
Northland are at hand. Financially, the present te
nology provides an encouraging atmosphere for all
sons' development. There is no need to wait or
surmise about what equipment the future may br
Adequate means are available to those with more t
a "talking" interest in the north. Certainly, equipm
failures will occur but these can be minimized if i
remembered that brains can be carried in less space
for less cost than can spare parts. Good planning, g
equipment and good personnel are the keys to pro
in the northern muskegs.

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M OILWEEK, DEC. 18/59

OIL, GAS ACCUMULATIONS IN ARCTIC A GOOD BET

By WM. H. PATTERSON
President, Trans-Western Oils Ltd.

The men who participate in Canada's far-north oil hunt will be faced with many special problems, but conditions there may not be quite as severe as they anticipate. It is known, for instance, that weather conditions are less extreme than in other areas far to the south. Daily maximum temperatures in July average 45 degrees above while winter temperatures are not as rigorous as those recorded in the Yukon. Geologists are interested in the number of piercement domes which exist in the Arctic and it has been said that "geological conditions make it reasonable to expect valuable accumulations of oil and gas may be found in the region." So far, some 40 piercement domes have been spotted.

To understand the nature of the area of the Arctic nds, let's keep in mind that it is the northernmost nsion of the oil and gas rich Canadian prairies.

Prospects For Oil and Gas

The explorer Stefanson as early as 1921 reported seeps of oil on Melville Island, and shale there which burned for fuel. The eminent geologist, W. E. Pratt, rs to seepages on the Arctic Islands which he wrote nfirmed the geological evidence." Fortier, McNair Thorsteinsson of the Geeological Survey are quoted writing "several large areas appear to have many simities to other regions that produce or have in reserve e quantities of petroleum." Bernier obtained 140 erial gallons of crude oil from a ton of Arctic Islands le.

Piercement Domes

Large numbers of piercement domes are believed to t in the islands, and 40 have been located. "Geological ditions make it reasonable to expect valuable accumulas of petroleum and natural gas may be found" in these nes, and "these structures strongly suggest interesting roliferous deposits in this sector comparable to occurces along the Gulf Coast of Texas." (Geological and nomic Minerals of Canada.) "The Sverdrup Basin . has piercement domes in a general geological setting sely similar to that of the Gulf Coast area of the U.S. l Mexico . . . The domes themselves are favorable ictures." (Vol. 36, No. 10, Bulletin of the A.A. of P.G.) omes in the Gulf of Mexico area have produced 22 ndred million barrels." (Oil and Gas Journal, Feb. 59.) ". . . Oil and gas reserves are known to exist in ry piercement-type salt dome in the Texas-Louisiana lf Coast." (Paper No. 4 Fourth World Petroleum Conss.)

Other Economic Products

It is suggested that metals of importance will be found the Canadian Shield to the east and south of the Arctic ands and that non-metallic minerals of importance exist the area itself. (There is a lot of gypsum and some phur.) Widespread coal has been found on Melville l other islands. Possibly a fisheries industry can be veloped.

It is now known that winter weather conditions are less severe than in the surrounding and to some extent populated continental areas. Summers are cool but remarkably uniform. July daily maximum temperatures average about 45° F. with the average minimum about 35° F. The absolute low reported is 60° below zero at Mould Bay one January, although tthe average absolute low for that month is 42° below. The absolute low at Snag in the Yukon Territory is given at 84° below, and at Verkhoyansk in sub-Arctic Russia—49° below. Calgary's absolute low is given at 49° below and Winnipeg 54° below. Hay River, just north of the Alberta border, has an average extreme low for January of 51° below.

Mean annual wind at Eureka is seven miles per hour, as against 11.4 miles at Toronto. Precipitation on most of the islands is below three inches a year.

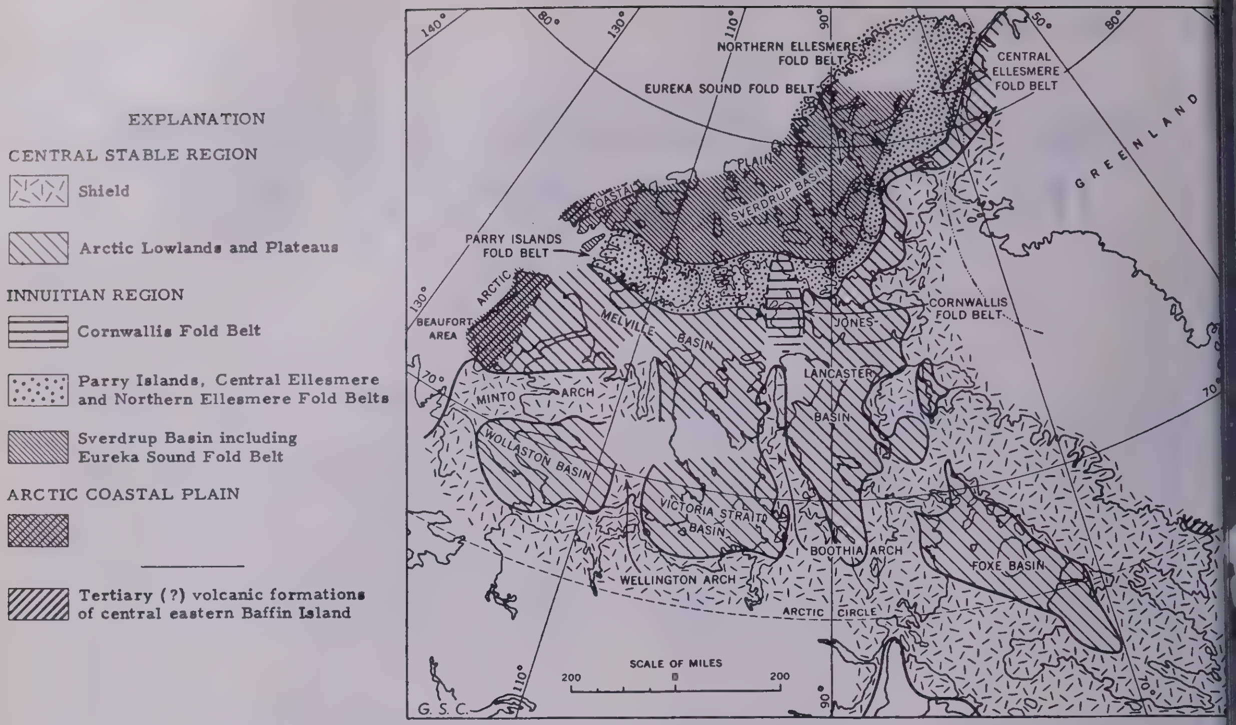
The ice of the Arctic Ocean is very much thinner than in the Antarctic, and there is no appreciable cap or glacial ice on the 80 to 90 million acres to be explored for oil. Ice islands are believed to come entirely from one glacier on Ellesmere Island. One ice island, first seen several years ago, and now 50 miles south of Isachsen, is to be used by Dr. Roots, co-ordinator of the Arctic Shelf Research Project, as his headquarters in that scientific project.

In Byam Martin Channel, between Bathurst and Melville Islands, spring tide is given as only one foot, and neap tide apparently is zero. A study of tides is included in the above project. Negligible tides should make for economy in harbor installations.

Transportation

One aircraft manufacturer is bringing out a helicopter suitable for transporting the heaviest piece of drilling equipment. (OILWEEK, May 22-59). As for fixed wing aircraft, Commander Calvert of the "Skate" reported the IGY station on a floating ice island had a landing strip usable during the winter months.

There is a network of government air routes and flying stations or airports throughout the islands. Flying boxcars and other heavy freight planes cover the area, and there are wireless stations at all these bases. OIL-



Geologic regions of the Arctic Archipelago are shown in this map from the Geological Survey of Canada.

WEEK quoting J. M. Harrison, director of the Geological Survey, reported that landing of aircraft presents virtually no problems; that winged aircraft can make wheel landings on the beaches, and ski equipped, can land on ice. (OILWEEK, March 6-59).

An aircraft company announced it would supply heated accommodation and meals at Resolute in buildings to be set up there, and to service aircraft at that point, and would maintain direct radio contact between forward camps and company offices everywhere.

Among aircraft companies offering constant flights to all D.E.W. stations and weather stations is one that will fly cargoes of 17,000 lbs. and passengers from Montreal to Alert, Resolute or other such stations. That company also offers P.B.Y. amphibians.

Lakes freed of ice by summer sun afford landing places for sea aircraft.

Marine Transportation

With the advent of the "Sir John A. Macdonald," Canada's 3,380-ton ice breaker, it is suggested that the "Northwest Passage" via Fury and Hecla Straits, Barrow Strait and M'Clure Strait can at long last be utilized by surface shipping, along the route followed by the Canadian motor vessel "St. Roch." Canada's new ice breaker is exceeded in size and power only by Russia's atomic powered "Lenin" and the U.S. Navy's "Glacier." The "Lenin" and other ice breakers maintain navigation across the whole of the Russian Arctic Ocean shore. This year, without the help of the "Macdonald," a fleet of 33 ships, including lesser ice breakers, sailed into various parts of the Canadian Arctic Ocean.

The most spectacular marine development relates to the submarine. Now comes word that the world's first atomic submarine cargo ship is slated to be launched from the Clyde, and make its maiden voyage in 1964. The vessel is being built for the Mitchell Engineering group of the U.K. The "Moby Dick" is to be of 50,000 tons and its first cargo is said to be 28,000 tons of iron ore from the Hudson's Bay. The consensus of repo is that the cargo submarine will travel sub-sea at appro mately double the speed, or with half the power requi by a surface counterpart. Planning is proceeding on s marine cargo ships in the U.S., Japan and Germany. T theory is that below the protective ice covering the s tanker will cruise in water always calm, with no vibrati no fog, no storms and no seasickness.

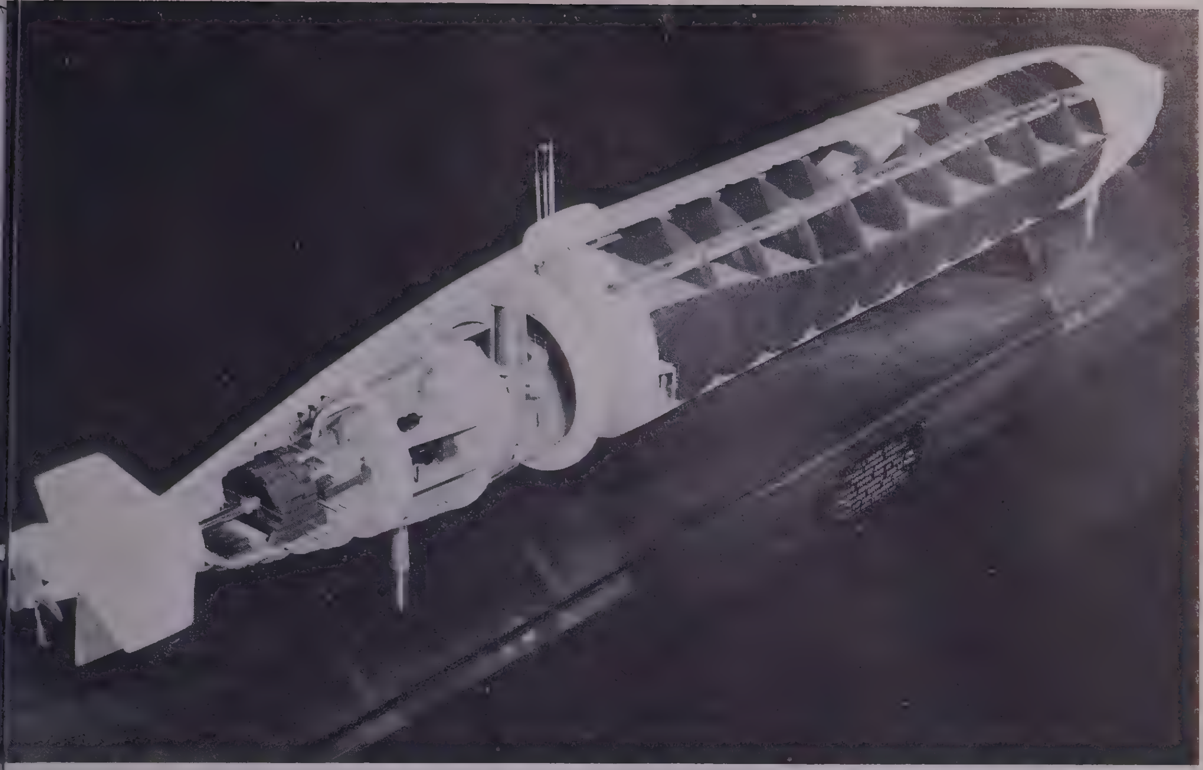
It is noted that in the great four lane highways un the ice, across the Polar seas, the "Skate" reported t shallowest soundings above the peaks of Lomonos Range to be 1,650 feet below sea level; confirming t safety of the Polar route.

The sub's fathometer, a sonar device, measures t distance to the sea bottom, echo finders measures t distance to the ice above, the television camera pictu the passing ice formations. Thus it seems clear that t sub-merchant ship will sail safely below the deepest and safely above the shallowest sea bottoms. The su most remarkable navigational instrument is the inert navigator which keeps track of the vessel's every mo ment in relation to the earth, measures the earth's ro tion at any given point, remembers where it has be and can also say precisely where it is. (From reports the cruise of the "Nautilus.").

Polyna harbors will be maintained free of ice by eje ing compressed air through perforations in pipes gridd across harbor bottoms, such as is done at Thule in Gre land. The bubbling water resulting prevents freeze- and resultant damage to harbor installations and vess

Pipelines

The pipeline has been termed essential in the Arc between islands and otherwise. There are increas examples of the flexible subsea pipeline. In operat "Pluto" a number of lines were laid across the Engl Channel to supply the Western Front. One suggest was for a line under the icepack with its output on t



Scale model of the Moby Dick, a 50,000-ton nuclear-powered submarine cargo ship, being esigned by Mitchell Engineering Corp. of England in conjunction with Saunders-Roe Ltd. The ackers hope to have the ship built and launched in 1964. With a length of 607 feet, the ship will ave a capacity of 28,000 tons at an underwater speed of 25 knots. If it materializes as scheduled, ne Moby Dick might provide the solution of how to market any oil reserves found in the Arctic slands, and thus could be a key to Arctic exploration.

t of Europe or elsewhere; another suggestion was the line should be to an Arctic seaport open for a weeks each summer. Flexible pipe was laid in the of Mexico by Shell. Magna Pipeline Company pro- s a flexible line from the BC mainland to Van- er Island, to be laid by cable ship.

At Goose Bay 10-inch pipelines, partly of special steel partly flexible, are being laid along the harbor bottom ervice a tank farm.

Tankers Versus Pipelines

Experience points to transport by tanker as preferable, anker rates are substantially less than pipeline rates. between tankers, the atomic submarine is showing ngth with its less expensive hull, economy in bunker space, smaller power requirement and greater speed, with fewer hazards.

Mv figuring of pipeline rates works out to three cents 100 miles per barrel, while spot tanker rates, since Suez crisis, work out to 4/5 cents per barrel per 100 ite miles.

Markets

The Arctic, during the present period of plentiful oil, ld doubtless look to North American markets. kered Arctic oil appears to have an advantage in ern Canada, and tankers could also reach the west t through the Bering Strait. Oil as a strategic material no doubt continue to have access to the U.S. market er cover of quotas or other protection. Japanese stry is showing increased interest in liquid petroleum The sea distance to Tokyo is not much greater than the distance from the East Indies, the production of which does not place it in the front rank and is decreasing. Statistics from World Oil, August 15/59, show that Japanese reserves of proven oil and gas are inadequate. Japanese production is less than 1/50th of consumption, and its reserves will last less than eight years. Middle East oil is twice as far from Japan as would be Arctic oil.

It is difficult to evaluate the European market in the light of Sahara production and the changing influences of the European common market and other groupings of nations. The exigencies of trade may admit Arctic oil to U.K. and other segments of the European Market, providing the advantage of a 3,300-mile haul as against the 8,000 miles from the Persian Gulf. The tanker distance from Venezuela to the U.K. is 2/5 again the distance from the Arctic Islands. It would appear feasible for the liquified petroleum gases of the Arctic to compete against the liquification of 500 million cubic feet daily as proposed in Venezuela.

There is an increasing trend in costs and footage required to check depleting U.S. reserves, while the trend in Canada is more favorable, and thus Canada looks with confidence toward the ever-expanding and greatest of all oil and gas markets—the U.S.

Geological exploration in the Arctic Islands appears to be no great problem. The Geological Survey of Canada has carried out surface reconnaissance in all of the Arctic Islands. In this work they have been assisted by the absence of overburden and the rock which outcrops everywhere. The Survey's mapping, based largely on

FROM OILWEEK, JAN. 2/60

ATOMIC SUBS

The story of the oil industry's all-out attack on the Arctic islands is now in the process of being written. As in no other area, the conquest of this barren land will depend upon technological weapons now under development. Despite the remoteness of the area, far northern oil would be within 3,300 miles of European markets if carried under the ice by submarine tankers. These vessels are now on the drawing boards in three countries: England, Japan and the United States. At the present time, atomic propulsion appears to be the only practical method of driving these huge sub-surface vessels safely and economically.

When—and if—Canada's Arctic islands are forced to yield up the oil which many geologists believe is there, it will be a triumph for many fields of science.

Ten years ago many of the ideas now being given critical study in the oil industry would seldom be found outside the pages of science fiction.

There has been talk—and serious talk—of a giant dam across the Bering Straits to raise the temperature of the Arctic Ocean. Scientists have spoken of vehicles without wheels flitting across the wasteland on a cushion of air; of plastic pipelines laid below the ice and drilling rigs borne by helicopters.

Transport Problem

Perhaps the most thorny problem oil men will face in the Arctic is getting the oil to market after it has been located. The most imaginative — and at the same time most practical — of all solutions offered so far appears to be the atomic-powered submarine tanker.

An atomic sub-tanker is no longer an idle dream. In at least three countries, plans for their construction forging ahead. Mitsubishi Heavy Industries in Japan vealed not long ago that such a tanker was in the wo the United States has already initiated studies and, Britain, the Mitchell Engineering Group is conduc hull tests on a pilot model of a sub-tanker.

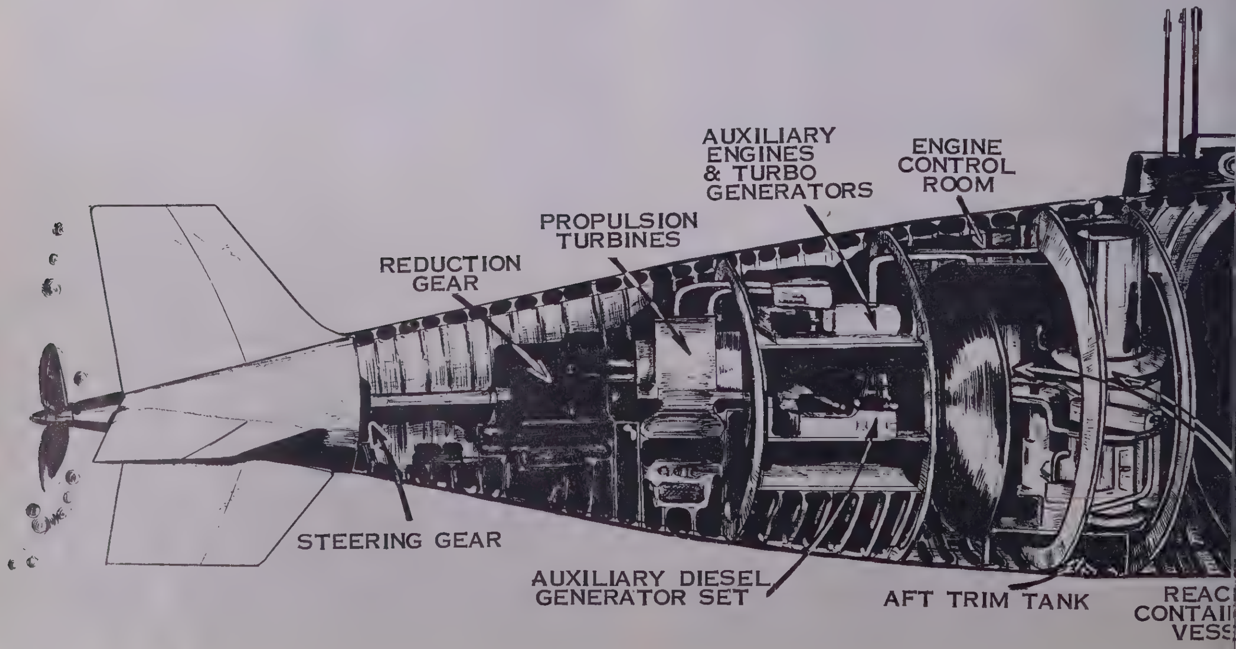
Working in conjunction with Sanuders-Roe L Mitchell has probably advanced farthest into the fiel

First Tests in 1958

Tank tests were first carried out by the group on Isle of Wight early in 1958. Results were positive eno to merit an order for full-scale design studies later same year.

In the spring of 1959, the design studies wer completed and immediately followed up by a vis to ice-bound Frobisher and Hudson Bay for an on the-spot examination of sea ice which was just cu minating a season's growth and was at its thickest.

The studies established beyond doubt that construc



ARCTIC OIL?

nuclear-powered submarine cargo vessel is a feasible osition with the materials already at hand and that a submarine could operate under the ice from ter-ls across the Canadian north during the "closed" on.

ccording to Mitchell Engineering, the following were ng the reasons for establishing the feasibility of such bmarine:

- The absence of wave-making resistance when the arine is fully submerged at its operating depth. means that less delivered horsepower is required rive the sub at speeds above about 20 knots than ld be required to power a surface tanker of similar l weight carrying capacity at equivalent speeds. The er the speed, the greater the submarine's advantage;
- Ability of the submarine to serve ports which are ed to surface vessels by ice during the winter;
- The ability to avoid the dangers, delays and dis-forts experienced by surface ships during bouts with weather;
- The strategic advantage of having a much better ce of proceeding undetected in war or time of emerg-

reatest advantage of all, perhaps, is an economic one. he event sub-tanker shipping can become competitive surface tankers on ocean hauls, Arctic oil, when d, would be much closer to fuel-hungry Europe than ht at first be realized.

Canada Closer

Oil from the far east, for example, must travel 8,000 s from the Persian Gulf to England while Canadian Arctic oil, transported beneath the polar cap by submarine tanker to London, would travel only 3,300 miles.

Combine this advantage with that of Canadian political stability and the prospect becomes even more attractive.

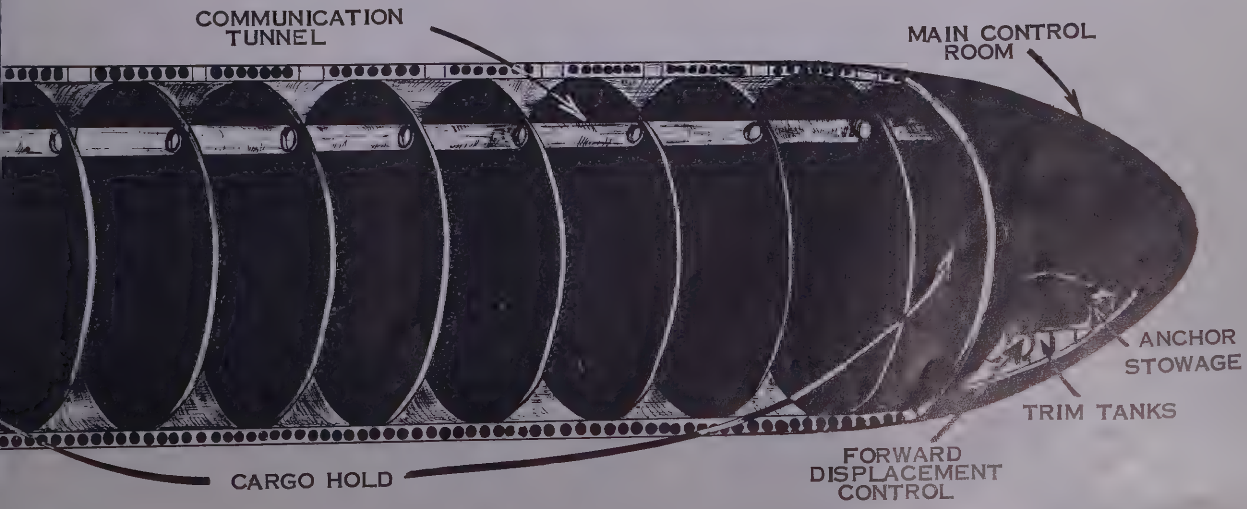
Now let's take a close look at the submarine tanker of the future and see exactly how it is likely to perform. An underwater oil carrier, for instance, should cruise comfortably at 30 knots or more. Mitchell engineers, however, seem to be thinking in terms of 50 knots and up.

Would Travel Deep

Its travel in deep-sea waters would possibly be at depths of 200-300 feet beneath the surface where the vessel—secure from storms and waves—could cruise along with a minimum of resistance.

One of the most important advantages of a sub tanker is that it can be of appreciably lighter construction than a surface vessel of comparable carrying capacity. In a surface tanker of 80,000 tons, the hull alone absorbs nearly 20,000 tons of steel, and in a 30,000 tonner, about 8,000 tons.

Japanese estimates suggest that sub tankers would require 20 percent less steel, a saving in structural materials due not only to the much simpler shape of a streamlined submarine, but also to the absence of mechanical stresses to which surface vessels are exposed by the heavy buffeting of waves and gales. External water pressures bearing on the sub's hull would be in large measure offset by the internal pressure of the oil cargo filling most of its shell.



No Fuel Tanks

Being atom-powered, our submarine tanker will, of course, require no bunker fuel tanks, which in a normal oil carrier may take up as much as 15 percent of total tonnage. Both for safety reasons and in view of anticipated difficulties in recruiting civilian crews for prolonged underwater cruises, it will probably be found desirable to run commercial submarines with a minimum of technical personnel. The degree of automation, of course, will depend almost entirely upon the type of atomic propulsion used in the vessel.

At the present time, the problem of squeezing high-powered reactors with their heavy anti-radiation shields into the streamlined confines of a submarine hull, sents the toughest problem the sub's designers have b called upon to face.

As the submarine's possibilities are examined many industry journals have come to accept the in evitability of these underwater cargo carriers. From a European source comes word that the giant Krupp works is interested in the whole field of cargo sub marines capable of using the polar route to reduc distances.

Krupp spokesmen point out that submarines are n operating at adequate depths for commercial transpo tion safely below the ice cap.

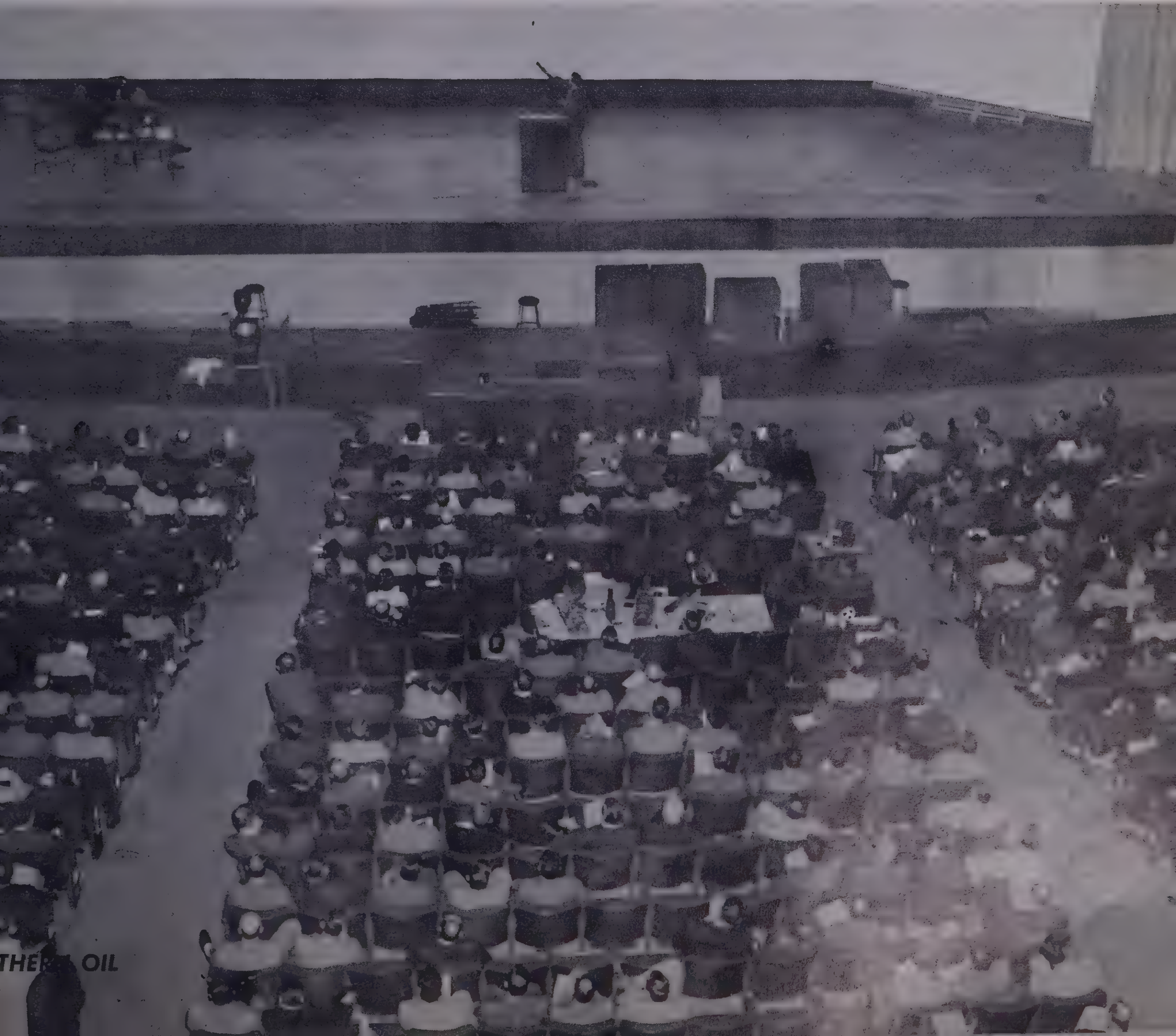
SYMPOSIUM USHERS ERA ARCTIC CO-OPERATION

The First International Symposium on Arctic Geology proved a strong magnet drawing interest from geologists and scientists throughout the world.

More than 1,100 delegates registered for the three-day session. When the symposium was first being planned a year ago, ASPG officials expected only about 200. Even two months ago they expected no more than 600.

The sessions dealt primarily with fundamental geology of the Arctic regions, and the direct search for oil reserves was barely mentioned in the 72 papers presented. Despite this, the prospects for development of large reserves in the world's last oil frontier was the basis for the intense world-wide interest in the session.

The symposium represented a large step in promoting exchange of geological information among the countries located on the rim of the Arctic Ocean. Further work is planned to keep these exchanges alive. Hope now exists for a new era of international co-operation in Arctic geological exploration.



The Arctic countries are on the rim of a circle formed by the Arctic Ocean. Exchange of geological information between these areas is considered vital. To the extent that the symposium, together with future activities, can promote the accessibility of this information, will its success be marked.

Hope for a new era of international co-operation in the development of the world's last oil frontier—the Arctic—appears to be the essential contribution of the First International Symposium on Arctic Geology.

The need for such international co-operation—in the form of exchanges of scientific and geological information—was probably the most apparent factor at the three-day meeting which drew more than 1,100 geologists and scientists from a dozen different countries. Repeatedly it had been stressed by top spokesmen at the meeting.

The need stems from the geographical and geological relationships of the Arctic countries (Alaska, Canada, Greenland, Denmark and Russia)—all located on the rim of a common circles formed by the Arctic Ocean. In order to attain the most accurate interpretation and most effective utilization of geologic knowledge in any of these given areas, it is vital to correlate this information with known geological conditions in other countries bordering this circle.

To the degree that the symposium can promote the exchange of this information will its success and contribution to future progress be marked.

Mountain of Facts

The symposium itself—with a geological mountain of information presented in a total of 72 papers—marked a large step in this direction. But of possibly even more importance are the prospects for continuation of future information exchanges.

To ensure that the steps now taken will be carried forward in the future, a provisional 20-man committee has been established to lay plans for a future Arctic geological symposium, and to discuss ways and means of promoting accessibility of information. The committee, headed by Dr. W. C. Gussow, geologist with Union Oil Company of California and president of the host Alberta Society of Petroleum Geologists, comprises members from Canada, the United States, Russia, Denmark and Greenland.

More Meetings

Site and date of the next Arctic symposium—likely to be held within three to five years—will be discussed by this provisional committee next August at the International Geological Congress in Copenhagen.

But a future symposium is not the only step which will be taken "to keep the ball rolling," as Dr. Gussow phrased. Entire proceedings of the first symposium will be published by the ASPG in a detailed volume t available within a year. The cost is estimated by Gussow "in the nighborhood of $50,000." The so will also publish several circum-polar maps, on the of 1:5,000,000. These will include a geological ma tectonic map and possibly climatic and hydrogra map, as well as a bathymetric chart of the Arctic Ocea

Other means of promoting information exchange be investigated by the committee, including the possib of a regular periodical publication containing geolog and scientific information from the Arctic countries.

"After getting the ball in motion, we don't inten drop it now," Dr. Gussow told OILWEEK. Final p for the publication of the big symposium volume not yet be completed, "and if we can't get the job d in Canada we'll go outside for assistance," he state

Dr. Gussow predicted that the symposium is "bo to have an influence on an international level," praised the Russians for their "complete co-operation

"The Russians have gone the limit in providing with information. They have held nothing back. Ru is so far ahead of us in the geological mapping and ploration of its Arctic areas, that their co-operation i immense value."

The symposium has not actually enhanced the p pects for the development of commercial oil reserve the Canadian Arctic, in Dr. Gussow's view, but "it provided us with a greater understanding of the prob so that we may more effectively pursue the challeng

Oil Incidental

Searching through the massive technical details in 72 papers, one would find that the word "oil" is ba mentioned. Only one paper—by Dr. J. C. Sproule— directly concerned with the prospects of finding an developing Arctic oil reserves. For the most part, papers dealt with fundamental Arctic geology, and peared to be of almost academic interest. "The s posium," as one observer pointed out, "was basic scientific, not commercial."

But there is no doubt that prospects of large oil serves in the world's vast Arctic sedimentary areas— last oil frontier—comprised the magnet which drew amazing response of global interest in the symposiun

A year ago, when the ASPG first started laying p for the symposium, they were thinking of attenda in terms of about 200. Two months ago they expe about 600. When the registrations were finally c pleted, the total passed the 1,100 mark.

Although the geologist superficially appeared to on "oil" as almost taboo, their lengthy delibera will provide a valuable, although possibly indirect, as ance in the practical search for oil reserves.

"A basic fundamental knowledge of the geolog conditions," as Dr. J. C. Reed, co-ordinator of the Geological Survey, commented, "is a primary esse for the exploration of petroleum reserves."

RUSSIAN GEOLOGISTS STRESS NTERNATIONAL CO-OPERATION

otentialities for oil and gas accumulations in the n Arctic and the Canadian Arctic are about "com-le" according to Dr. F. G. Markov of the Institute eology, Leningrad. Dr. Markov is the head of a man Russian delegation to the ASPG's Arctic Sym-m. The other two are: Dr. M. I. Rabkin and Dr. Sachs, also of the Institute of Geology. They are mpanied by their interpreter, Mrs. T. F. Lokhova.

r. Markov pointed out that the Russian Arctic areas the same geological sections as the Canadian Arctic similar evidence of structure, which would result ughly "comparable" oil and gas potential.

Far Ahead

ussia, however, appears to be far ahead of Canada s Arctic oil search. Dr. Markov was surprised to that the first well within the Canadian Arctic circle is just now being drilled (Richfield et al Grandview, on the Mackenzie River, some 75 miles south of the Arctic Ocean). He could not say precisely how many wells have been drilled within the Russian Arctic, but said that there had been "quite a number." He disclosed that Russia is conducting a long-range core-hole drilling program to study the stratigraphy of the area, and, to date, Russia has found three salt-dome type structures bordering the Arctic Ocean with promising oil potential.

Co-operation Vital

International co-operation is essential in order to achieve maximum effectiveness of geological information, Dr. Markov pointed out, and praised the ASPG Arctic Symposium as a step in the right direction in this matter. He added that the Russian delegation will leave behind them the text of their papers to the symposium, together

Russian delegates to the First International Symposium on Arctic Geology expressed appre-ciation for friendly reception received in Calgary. Shown above, they are, left to right: DR. M. I. Rabkin and Dr. V. N. Sachs of the Institute of Arctic Geology, Leningrad; interpreter Mrs. T. F. Lokhova, and Dr. F. G. Markov, also of the Leningrad institute, who headed the Russian dele-gation.

with their maps and diagrams, to be published in the volume on proceedings of the symposium.

"Papers on Soviet geology published in Russia are available for distribution throughout the world, and assist in correlation of geological information," Dr. Markov stated. "In order to interpret geological information in any given country as accurately as possible, it is essential to correlate this with information from adjacent countries." In this connection, Dr. Markov revealed that he has made extensive use of Canadian papers on the Canadian Arctic in his own geological work on the Soviet Arctic.

Questioned about the suggestion that the next s posium on Arctic geology in about four years be in Russia, Dr. Markov pointed out that one of the sess of the International Geologic Congress has been hel Russia, and that the Arctic symposium might well fo suit.

Dr. Markov expressed appreciation for the "warm friendly" reception that his delegation has receivec Canada, and stressed the fact that they came to n as great a contribution as possible to the internati exchange of scientific and geological information.

DOUBLE EFFORT FOR GSC'S ARCTIC GEOLOGIC MAPPING

Funds and staff for the Geological Survey of Canada will be doubled in an effort to speed, by geological reconnaissance, mapping of Canada's Arctic areas, Northern Affairs Minister Alvin Hamilton told the symposium delegates.

The mapping has so far been completed on less than half of the northern areas, and previous plan had called for completion early in the 1970's. But this, according to Hamilton, is not fast enough to meet the needs of northern development work being planned or carried out by the government, the oil industry and the mining industry.

A crash program for preliminary reconnaissance geological mapping of the Northwest Territories, Yukon Territories and Arctic Islands will be carried out by the Geological Survey of Canada.

This announcement was made by Northern Affairs Minister Alvin Hamilton who said in an address to the Arctic Symposium banquet that the efforts of the GSC are being doubled. The announcement was received with marked enthusiasm by the geologists attending the banquet.

First Steps Taken

Mr. Hamilton told the meeting that the "government has just taken the first steps to provide the survey with the additional staff and funds required to double its present efforts during the next five years."

In outlining the needs for government research to promote mineral and oil development in the far north, Mr. Hamilton made the following points.

► "First, and most obviously, we need to speed up the production of new and more complete topographic and hydrographic charts.

► "Secondly, we must increase the rate at which the Geological Survey can provide basic data in the form of geological and geophysical maps.

► "Thirdly, we must provide oceanographic data for the proper understanding of conditions in the Arctic Ocean and to ascertain the mineral potential of the polar continental shelf.

► "And fourthly, we must encourage and support all forms of research that will have a bearing on the development of the north."

He added that "support of research deserves the fullest co-operation from all segments of the economy, because without basic scientific knowledge of the north, the economy of the whole country will suffer."

Mr. Hamilton pointed out that in 1952 the GSC had completed preliminary geological reconnaissance mapping of only 32 percent of the Yukon and 10 percent of the Northwest Territories, while by the end of 1959 this had been increased to 39 percent of the Yukon and 36 cent of the Northwest Territories. Including the A Islands, close to half the area has now been map with the bulk of the work done during the past se years.

Helicopters Invaluable

"This great increase is due to the survey's pionee and successful use of helicopters and, more recently small fixed-wing airplanes, in reconnaissance work," Hamilton stated.

The present program calls for virtual completion this mapping project by 1970, but Mr. Hamilton stres that "this mapping will be only the initial reconnaissa investigation, and that probably not even one perc of the geologically favorable areas will have been stuc in any detail. It is obvious, then, that geological st in the north will only be starting at the end of decade."

Mr. Hamilton announced that he expects the gov ment to support a recommendation to speed up a gram of aeromagnetic surveys by "enlisting the aid commercial air-survey organizations, so that aeromagn maps of all Pre-Cambrian areas in the Territories also become available within the next decade." stated that "aeromagnetic surveys . . . provide a ra relatively inexpensive, supplementary source of ge gical information which is proving particularly valua over the Canadian Shield."

Other Programs

In addition to the reconnaissance mapping be carried out, Mr. Hamilton outlined other programs be conducted or planned by the GSC and other agenc These include:

► "Research on how other geophysical and g chemical studies might provide more useful and imp ant data in the search for mineral deposits.

► "Geochemical studies in conjunction with rec naissance mapping in northwestern Ontario during 1 and 1961. If it is successful in thus providing m

ALVIN HAMILTON

. . spurs northern resources development..

ct indications of favourable prospecting areas, the hod can be applied in more northern territories in r years.

► "More intensive studies of Pleistocene deposits ch are so valuable and important in engineering lies.

► "The study of permanently frozen ground . . . and relation to supplies of groundwater.

► "A polar continental shelf project, carried out last r, used '16 scientists and technicians who made a liminary survey of the area to study transportation blems and other working conditions,' and will be owed up this year by '60 scientists and supporting f,' who will start a systematic study which will take number of years to complete.' The research will in- de a detailed geological examination of the islands the sediments, extending from the shoreline out over Continental Shelf, the oceanography and hydrography the Shelf area and the inter-island channels, the geo- phy of the islands, and the collection of gravity and gnetic data and of biological information regarding dlife and fisheries.

► "Construction of a 4,600-ton research ship, the G.S. Hudson, which will be strengthened to work in . This and similar ships in the design stage 'will be ovided with equipment to obtain bottom samples and g sediment cores. Information about the sediments tween the islands and in the bays will provide valuable pplementary geological data of the area.'

► "Establishment of the Bedford Institute of Oceano- aphy at Dartmouth, Nova Scotia, 'to provide necessary commodation and facilities for the carrying out of this anned research program in oceanography.' Slated for mpletion in five years, the Bedford Institute will be the eadquarters of the polar group of oceanographers, hydrographers, geologists and other scientists working in the far Arctic'."

Hamilton congratulated the industry on its vision in foreseeing economic development of far northern oil reserves, and said that the government's activities are centred around a national resources development program.

"More Co-operation"

"But government action alone is not enough," he warned. "We need more co-operation between government and industry, and more basic research by government, industry and universities.

"In a country where mineral resources bulk so large in the total economy, we cannot afford to pass up any avenue of research that may lead to the discovery of new deposits to replace those being depleted at such a high rate today."

★ ★ ★

Claims GSC Work Provided Basis For Symposium

The Arctic Symposium could never have taken place without the preliminary geological work on the north which has been carried out by the Geological Survey of Canada, according to C. S. Lord, chief geologist with the GSC.

In an interview with OILWEEK, Mr. Lord pointed out that the geological information on the Canadian Arctic which has so far been uncovered is based almost entirely on the preliminary work carried out by GSC field parties.

The GSC's contribution to the geological knowledge of the Canadian Arctic is borne out by the fact that of the 72 papers given, six were from the GSC. Several more were from other government research projects, and if contributions from the U.S. Geological Survey and other government bodies in Greenland, Russia and Denmark are included, close to half the papers originated from various governmental research agencies. And most of those which did not, have at least drawn heavily upon the preliminary work by the GSC and other government bodies.

GSC Findings Spark Boom

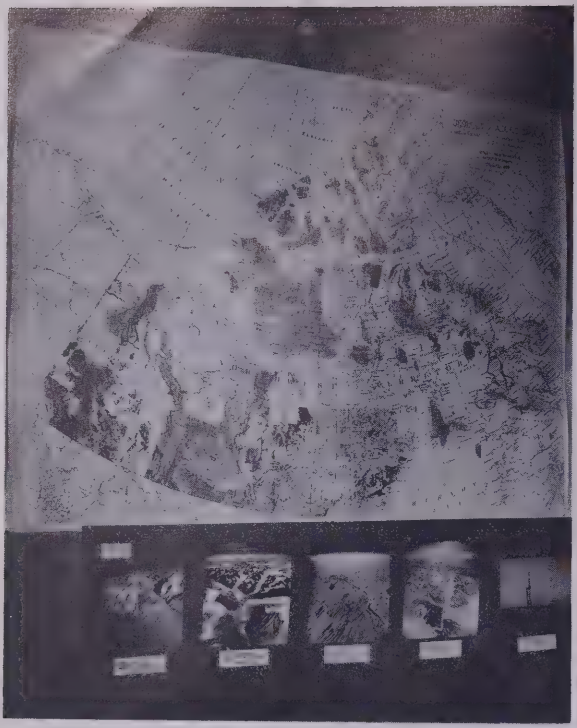
Mr. Lord stated that the rush of oil companies into the far north and the Canadian Arctic Islands—where more than 100 million acres have been filed on in the last year—is based directly on the geological reconnaissance mappings and preliminary reports prepared by the GSC.

"Without this preliminary work of the GSC, this far northern activity by the oil companies would never have got underway," Mr. Lord stated.

How is Canada doing in its program of geological mapping of its Arctic areas in comparison with similar work being carried out in Russia?

Russia, Mr. Lord admitted, is well ahead—but in his view a comparison is not valid. Conditions of climate, permafrost, population, terrain, accessibility and transportation facilities within the Arctic areas are all loaded heavily in favor of Russia. Mr. Lord pointed out that in the Russian Arctic, heavy timber extends almost to the Arctic Ocean, the terrain is considerably less formidable, the climate more favorable and the population much greater.

"If Russia had the population of Canada and faced identical physical conditions and vast distances from the centres of population, would its northern development



Geological reconnaissance mapping in the Northwest Territories, Yukon Territories and Arctic Islands is shown in the above map, part of an exhibit by the GSC at the symposium. The GSC still has more than half of the northern territory to map, and should have it completed before 1970 with the stepped-up program announced this week.

still be greatly advanced over the development of the Canadian north?" Mr. Lord asked. "I doubt it."

Use Own Standards

Canada's Arctic development program should be measured by its own standards, rather than by invalid comparisons with Russia, Mr. Lord claimed, and by these standards the progress is quite notable.

Turning to his own department's program of geological mapping, the GSC's chief geologist admitted it could profitably be stepped up, and in this connection welcomed the announcement by Northern Affairs Minister Alvin Hamilton that the staff and funds for the GSC work will be doubled.

"This should result in the completion of reconnaissance mapping of the north considerably before the previously estimated date of some time early in the 1970's," Mr. Lord stated. He added, however, that despite whatever resources or funds may be poured into the program, it will still take considerable time to complete the mapping.

Pioneered Aircraft Use

The use of light aircraft—both helicopter and more recently fixed-wing aircraft—for reconnaissance surveys in the north was pioneered by the GSC, greatly increasing the speed of work with the result that the GSC has been able to map more than half a million square miles in the past eight years.

The first GSC field party to employ helicopters was headed by Dr. Lord in 1952. Dubbed "Operation Keewatin", the party carried out field investigations and geological mapping in the Keewatin area of the North
Territories, adjacent and to the west of Hudson's B

In addition to preliminary mapping of the Arctic s
mentary areas, the GSC has recently been conduc
aeromagnetic surveys, and in 1959 some 9,000 mile
widely-spaced aeromagnetic profiles were flown in a 1
geological exploration program, Operation Franklin,
the Arctic Islands. Aeromagnetic surveys are expe
to provide useful data for the geological study of
area.

* * *

U.S. Geological Survey Basis For Big Alaska Oil Rush

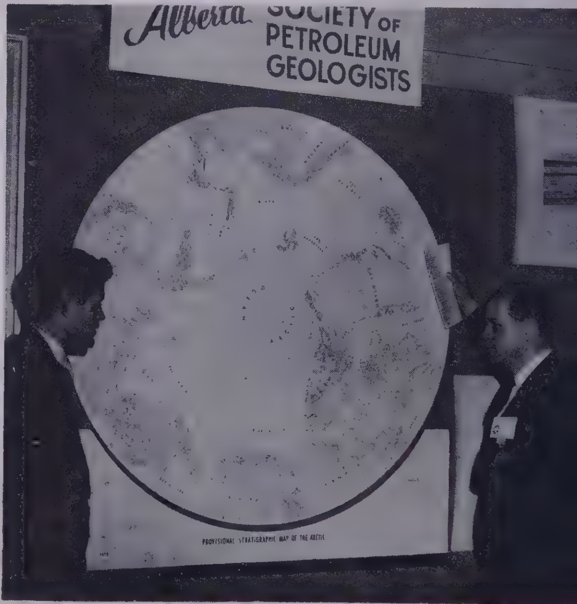
The hope that the Arctic Symposium will lead
increased accessibility of Russian Arctic geologic kn
ledge was expressed by Dr. J. C. Reed, co-ordinator
the United States Geological Survey, in an interview w
OILWEEK.

"The outlook is more encouraging," Dr. Reed not
He also stated that up to now he has not found
accessibility of geological information from Russia to
as great as he would like it.

Need Russian Knowledge

The USGS's interest in Russian geology stems fr
its geological work in Alaska and the need to correl
the Alaskan knowledge with geologic knowledge fr
Russia and other Arctic areas.

"The Arctic areas—Alaska, northern Canada, Gre
land and Russia—are all closely related on the rim o
circle formed by the Arctic Ocean," Dr. Reed explain
"Common geological conditions exist to a large deg
on all sides of this circle. Because of this it is vital


Alberta SOCIETY OF
PETROLEUM
GEOLOGISTS
PROVISIONAL STRATIGRAPHIC MAP OF THE ARCTIC

E. W. Carter of Carter Mapping Ltd. shows OILWEEK managing editor Earle Gray the base map of the circum-polar area which will later be used to prepare geological and tectonic maps of the Arctic on a scale of 1:5,000,000. The maps will be published this year by the Alberta Society of Petroleum Geologists, together with a detailed volume containing the complete technical proceedings of the three-day symposium. The effort is expected to represent about a $50,000 publishing venture.

elate the known conditions in one area with those ther areas in order to achieve maximum utilization of ogical knowledge."

The international exchange of this information is "the essence" of the Arctic Symposium, in the view of Reed, and the success of the symposium will be ked in large measure by the degree of information ange and accessibility that it achieved.

Exchange A Benefit

Dr. Reed expressed the opinion that this exchange of rmation will be of direct benefit to the industry in exploration efforts for northern oil reserves.

"Fundamental scientific knowledge is the basic ssential in the exploration for petroleum reserves," e stated. "And it is because this is so that the rctic Symposium has drawn such tremendous in- erest."

Geological mapping in Alaska is carried out by a arate Alaskan branch of the geology division of the . Geological Survey, and the methods of reconnais- ce mapping carried out in Alaska are similar to those d in northern Canada, Dr. Reed explained. The . and Canadian Geological Surveys, in fact, assisted h other in establishing the use of helicopters for map- g and geological exploration work.

Basic geological mapping is the "heart of the job" USGS in Alaska, and to date more geological recon- ssance maps on a scale of 1:250,000 have been com- ted covering more than half of the state. Present work being concentrated in southeast Alaska and along the skan Panhandle where the oil industry's exploration rts are now concentrated.

Boom Results

As the big land rush in the Canadian Arctic islands a direct result of the work of the Geological Survey Canada, so the present oil exploration boom in Alaska direct result of the work of the USGS.

The oil industry's interest was focused on Alaska owing the publication of USGS bulletin No. 1094, out five years ago", which outlined the potential oil ducing areas in Alaska. Interest in Alaska was further reased by the discovery of oil on the Kenai Peninsula Richfield Oil Corporation in 1957.

'The areas filed on by oil companies follow almost ntically the outline of the potential oil producing areas described by the Geological Survey," Dr. Reed de- red.

While cautious about expressing an opinion on the spects of Alaska developing into an important oil pro- cing state, Dr. Reed declared that the outlook is "en- raging," and that the present "oil rush is more import- than the famed Alaskan gold rush."

★ ★ ★

SN Commander Says 20 Years efore Atom Subs Commercial

Atomic submarines may play a vital role in the velopment of oil resources in the Canadian Arctic ands, but it's likely to be 20 years or more before ese subs are "commercially economical."

That was the opinion expressed by Commander James Calvert, commander of the USN atomic submarine ate, at a banquet address to delegates of the Arctic mposium Monday evening.

Cmdr. Calvert stressed the fact that atomic submarines e "tremendously expensive to construct and complex to operate. They may be practical for the resources of a wealthy nation for military purposes, but they are not practical at the present time for commercial use."

Cmdr. Calvert pointed out, however, that physically the atomic submarines are ideally suited for both exploration and transportation purposes of the deep Arctic basin, adding that they may well be used in the future to supply northern oil to help meet "an exploding world demand for fossil fuels."

Some Dissention

The commander's forecast of a 20-year period before atomic submarines become practical met with considerable dissention from a number of oil industry spokesmen. Symposium chairman Dr. T. A. Link, in expressing his thanks to the speaker, told the banquet delegates that he disagreed with Cmdr. Calvert's 20-year forecast, and made a tongue-in-cheek forecast that they would be developed for commercial transportation within 10 years.

Another industry spokesman—a consulting geologist who has been studying the possibilities of commercial transportation by atomic submarine—stated that both England and Japan appear to be "more advanced with their planning for an atomic submarine tanker." Another spokesman confirmed this, stating that he has found England and Japan to be "optimistic over the prospects," while the U.S. Maritime Commission, which has also investigated atomic submarines, appears to be pessimistic.

500 Hear Talk

Despite the fact that not all the delegates accepted his forecast, Cmdr. Calvert received a standing ovation from a capacity crowd of more than 500 delegates who packed the Hotel Palliser's dining room to hear the commander recount the Skate's two voyages beneath the polar ice pack.

He described the Arctic Ocean as "an area of destiny, covering five times the area of the Mediterranean and

CMDR. J. F. CALVERT
. . . a pessimistic forecast?

twice the area of the United States." Ideally suited to underwater navigation, the Arctic Ocean has an average depth of about two miles and a comparatively thin ice pack of about 10 to 12 feet. He described the thin ice cover in relation to the depth of the water as being analogous to the paint on the ceiling of a large room.

Mountains Charted

Built in 1957, the Skate travelled a total of some 5,500 miles under the polar ice during 1958 and 1959. On the first voyage during the summer of 1958, the Skate surfaced several times through small openings in the ice cover which were located by sonar instruments. The ship explored and traced with its sonar equipment the underwater Lomonov Mountain range which stretches across the Arctic Ocean from Greenland to Siberia, and successfully located and surfaced within 50 feet of drifting polar ice station Alpha, at the time carrying out research for the International Geophysical Year program.

During the second voyage in March, 1959, the Skate was assigned to surface at the North Pole by breaking through the polar ice cover. The Polinyas, or open-water breaks in the ice, are frozen over during the winter, and the Skate's sonar equipment had to locate a patch of thin ice which represented a former Polinya, and then ram through this ice cover. U.S. Navy researchers had been unable to predict the maximum thickness of ice that the ship would be able to break through.

On March 17, the Skate located a small, thin ice patch at the North Pole, manouvered directly under it, and attempted to ram its way up through. The first contact with the ice sent the ship reeling some 175 feet back down through the water. A second, more forceful attempt crashed the ice, and the Skate emerged into the bitter cold Arctic winter dark, greeted by an observing polar bear.

★ ★ ★

Mining and Oil Industry Co-operation Held Vital

Co-operation between the oil and gas industry and metallic minerals industry in the development of Canada's north was advocated at the closing day session of the Arctic symposium by Dr. J. S. Sproule, Calgary consulting geologist and president of the Canadian Institute of Mining and Metallurgy.

Dr. Sproule claimed that co-operation between the two groups would "work wonders," and mentioned three examples:

(1) Mutual transportation facilities would cut costs for both groups.

(2) Mutual services essential to any northern developments would also cut costs.

() The establishment of metallic industries would create markets for the oil and gas industry, helping to finance the latter's exploration work.

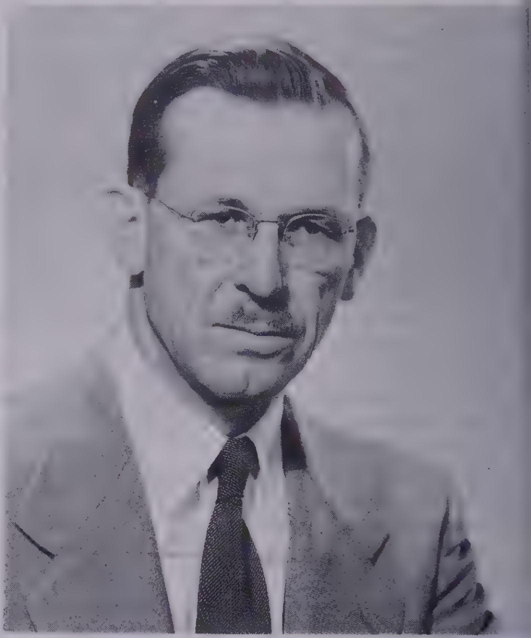
Should Study Markets

"I would not conclude that the oil industry should plunge head-long into a development program in the Arctic areas without giving considerable thought to markets both at home and abroad. I do conclude that those concerned with development of both metallic and non-metallic mineral resources would do well to get together in their planning to lighten the burden for both groups. Authorities agree that the area is rich in natural resources and that it is merely a question of time and technical know-how. Why wait 50 years if we can do it in 25 years? Why wait 25 years if we can do 10 years?",

Dr. Sproule predicted great development of northern ares within the next decade.

He said that a program of mutual co-operation bet the oil and mining industries in the north "is a na objective of the CIMM, and added that he lieves the federal Department of Northern Affair planning to give active support to this objective by d all possible to bring the two groups together.

Dr. Sproule voiced opticism on the ability of the n country to support a tremendous increase in popula and claimed that the potentialities for agricultural acti in the north country, as one example, are better than t are generally regarded.



J. C SPROULE

. . . oil and mining should get together.

Geology "Ideal"

Reviewing the prospects for development of oil serves in the Canadian north, Dr. Sproule said that "geological setting is as ideal as one could expect," added that "oil should be cheap to develop." He m tioned that there are "abundant" oil seepages wh "speak well of the production possibilities." He pointed out that the geologic section is thick, the str tures are large and also abundant, and the source ro for oil are present in quantity.

Dr. Sprouls pointed out that not only would the industry benefit from the establishment of metallic dustries, but these industries in turn would benefit fr the presence of cheap sources of fuel.

Commenting on the outlet for markets for north oil, Dr. Sproule conceded that the present picture not too bright, but mentioned as possible future mark Japan, Europe, the Atlantic and Pacific seaboards, the interior of Canada, in addition to the prospects o growing market in the north itself.

He pointed out that Europe is less than a third distance from the Canadian Arctic Islands than it is fr the Persian Gulf where it now obtains a large port of its petroleum needs, and that Montreal might be c sidered as a large potential market.

ONE WORLD – THE NEW GEOLOGICAL CONCEPT

The 72 papers presented at the First International Symposium on Arctic Geology are expected to form a vital contribution of lasting value to the geological and scientific knowledge of the world's Arctic areas.

Last week, *OILWEEK* presented the news highlights of the tightly-packed, three-day meetings. On the following pages are presented comprehensive digests giving the essence of the material in some of the most significant papers, as well as the impressions of a leading geologist on the symposium's discussion periods and a personality profile of the symposium chairman, Dr. T. A. Link, one of Canada's most honored geologists.

The digests presented in the following pages range from an outline of the tectonic developments of the central Soviet Arctic to a method for accelerating the melting of ice and snow by artificial dusting. Devonian stratigraphy in the Mackenzie River basin is discussed by Dr. H. G. Bassett of Shell Oil; the oil, mineral and population potentials of the Canadian north are outlined by Dr. J. S. Sproule, while the geological interpretation of aeromagnetic profiles from the Canadian Arctic is presented by a team of scientists from the Geological Survey of Canada.

DISCUSSIONS PROVE WIDE INTEREST IN SYMPOSIUM

By L. E. WORKMAN
Canadian Stratigraphic Service

The symposium presented to geologists "a unique opportunity to begin to understand the geology of the world as a whole by extending their knowledge southward from this world-circling region," in the opinion of this distinguished geologist who here presents his resume of the discussion periods, prepared exclusively for *OILWEEK*.

A question-and-answer period covering a vast range of topics was held on the second and third evenings of the symposium on Arctic geology. The range of questions was almost as wide as the range of original papers, which indicates the extent of the interest in all phases of Arctic study and exploration. The delegates discussed such large-scale theories as the effect on the continents and the great mid-Atlantic ridge of the movements of the earth's crust, and also such minute items as pollen and spores and the rock age they indicate.

Bruce C. Heezen, of the Lamont Geological Laboratory, spoke of the significance of the mid-Atlantic ridge in connection with the so-called "drift" of the North and South American continents away from the Europe and African continents. He stated that the continents were not masses floating apart from each other like icebergs, but rather that a continuous growth of the ocean floor from below spread apart the earth's crust on which the continents are situated. Wegener's original description called it "continental displacement" which is much better than continental "drift".

Interest High

Much interest was shown in Heezen's description of world-encircling extent of the Mid-Oceanic Ridge, not only crossing the Arctic but recognizable in the Indian Ocean and the South Pacific. Extensions of these and similar belts of movement can be traced into the continents. He was unable to state how the Rocky Mountain Trench fits into the picture but suggested that lines of movement extend northward from the San Andreas fault, the Sierra's, and the Rocky Mountains.

In answer to an inquiry Heezen pointed out how important the large number of Soviet soundings were to prove the extension of the Mid-Atlantic Ridge under the Arctic Ocean. Also the sonic profiles obtained by the under-ice voyage of the Nautilus showed the typical sharply mountainous character of the Mid-Atlantic Ridge.

The Soviet geologists had emphasized the presence of large anticlinal and synclinal regions represented by the strata situated on still larger "platform" areas. For these they devised the simple terms "anticlise" and "synclise". The symposium was interested in the use of these terms and found them very descriptive. The terms were described as representing structures 100 kilometers, or more, in width.

Character of Sediments

Much interest was shown in the characters of the sediments all around the Polar region. The Russians described the rocks in Siberia, Greenland rocks were described by a member of the Greenland Survey, Canadian rocks by the Canadian Survey, and Alaskan rocks by the Un
States Survey representatives. Inasmuch as Canad
closest at hand, the most interest was expressed in C
dian geology. Lively discussion was brought forth b
paper on Stratigraphy of the Mackenzie Region by H
Bassett, of Shell Oil Company, and T. P. Storey
Husky Oil and Refining Co. These held particular
terest because they dealt with possible oil-produ
rocks in the Northwest Territories. The discuss
brought to the realization of the delegates how large
Arctic region is and yet how enormous an amoun
geologic information it was possible for a single pe
to hear and understand after having been analyzed
the numerous persons working in the difficult area.

W. B. Harland, of the University of Cambri
England, spoke of glacial deposits in Spitsbergen of
Cambrian age, and L. Koch, of the Greenland Sur
mentioned the same type of deposits in Greenland. Gr
land appears to have entered a long period of folding
igneous activity after Ordovician time, there being
sediments since this early geological period. Koch
mentioned an enormous lava deposit extending from
land to Scotland, as being part of the deposits du
these mountain-making times. He does not believe t
has been any movement in Greenland since the ice

J. C. Sproule, of J. C. Sproule and Associates
answer to a question as to what are the most signifi
structural belts in the Western Canada Basin, poi
to the three-northeast-southwest belts of faulting exte
ing through Lake Athabasca and the Peace River, thro
Great Slave Lake and Fort Nelson, and a similar
further northwest.

There was considerable interest in the discussion
the Soviet and Canadian geologists alike that since
recession of the continental glaciers, 10,000 or so y
ago, the beaches have risen to stand 100, 400, and e
1,200 feet above their former position at sea level.

It was brought out by V. N. Sachs, of the Insti
of the Geology of the Arctic, Leningrad, that the Sov
receive all publications from every source that they t
they might need. They can usually translate for th
selves, but they have the most exhaustive abstrac
service in the world, so complete that the best way
other countries to get all abstracts would be to retrans
the Russian abstracts.

The First International Symposium on Arctic Geol
presented to the geologists in attendance a unique op
tunity to begin to understand the geology of the w
as a whole by extending their knowledge southward f
this world-circling region.

ARTIFICIAL MELTING A SUCCESS

PLEISTOCENE GEOLOGY OF WESTERN CANADA

By J. G. FYLES and B. G. CRAIG
Geological Survey of Canada

:pose of the paper was to summarize the events
took place in the Canadian Arctic during the
cene Age as geology is now able to reconstruct
e information was gathered during the course of
air-mapping survey traverses conducted by the
s between Hudson's Bay and the Cordillera, which
d some 500,000 square miles of land.

e Arctic has undergone periods of glacial expansion
ersed with periods of warmer weather as in the
cene. So far, geologists recognize three clearly
d glaciations. Some of the Arctic islands show
ce of carrying local ice caps other than the glacia-
eposited during these three periods.

idence of pre-Wisconsin events is, largely, to be
on these islands. Most prominent of these is the
ort Formation, a succession of gravels, sands and
p to a depth of 200 feet. They are unconsolidated
orizontally stratified and are scattered with mixed
ntrations. Wood appears uncompressed and ex-
y fresh with logs up to one foot in diameter in
ice.

Samples Studied

llen samples from the Beaufort formation have been
d by the GSC. The authors secured five samples
southern Banks Island and it was found that the
two samples contained a pollen flora of northern
rs such as spruce and firs as well as some hard-
. The upper Beaufort, however, showed much less
ion and no hardwoods at all.

n western Banks Island—and probably many others,
eaufort is overlain with glacial till succeeded by
silt containing peat and beaver-chipped sticks.
-carbon tests place the age at more than 35,000

**The Mackenzie area is typified by many very
ck layers of sand silts, clays and gravels which
ely include an entire series of geological units.
len analysis from the area indicates climatic con-
ions similar to those encountered today although
bon tests show an age in excess of 40,000 years.**

he paper went on to deal with ice movement in
rctic during the periods of glaciation. From study
e various characteristics, the authors were able to
e the Laurentite ice sheet into two zones; a peri-
l zone and a central zone where the features in-
e a rapid and regular retreat which culminated in
Keewatin Ice Divide.

eferring to Victoria and Banks Island within the
heral zone, it was found that, even at a maximum,
ce was never particularly thick and as soon as de-
ation began the thinning ice stagnated on the higher
on Banks Island and on the interior of Victoria. In
ow areas, which now make up the coastal indenta-
of bays, straits and channels, large areas of ice con-
d to move and produced morrainal lines and heavy
s.

n the mainland, in the area of Great Bear Lake and on parts of Victoria Island, there are great areas of hummock-like morraines.

★ ★ ★

INVESTIGATION INTO METHODS OF ACCELERATING MELTING OF ICE AND SNOW BY ARTIFICIAL DUSTING

By K. C. ARNOLD
Canadian Department of Mines and Technical Surveys

A thin layer of dirt spread over snow or ice increases the rate of melting due to an increase in absorption of solar radiation. In the recent past, this fact has been the subject of both quantitative and qualitative investigations in Canada while, in Russia, experiments have been going on since 1885. Purpose of the paper is to record results of a quantitative estimate of the relative effectiveness of cinders and ash differing in particle size and the addition of salt and sand in varied concentration. The experiments were conducted on Ellef Ringnes Island. During the investigation, the sun remained above the horizon.

Fresh Water Tested

Ice to be tested was chosen both from the sea and a fresh-water lake inland. In each case the ice—which was about 2.5 meters thick—was cleared of snow, and divided into plots. Seven different materials were used.

Most effective material appeared to be fine cinders. In one investigation, snow covered by the cinders melted down more than 15 cm, while the adjacent control area gained three cm. Presence of salt was found to be highly effective during the initial stages but it declined sharply in value after a short period. After about one month it was found that the ice covered by the cinder mixture had melted down about one meter but the action had slowed markedly by that time due, probably, to the screening effect of melted water in the pool.

The experiments indicated that artificial dusting is only 60 percent as effective on fresh water ice as on sea water ice. As a result, it has been concluded that there is a significant difference in actions though no explanation was put forward.

★ ★ ★

RADIOCARBON DATING OF RAISED BEACHES IN NORDAUSTLANDET SPITSBERGEN

By W. BLAKE
Postgraduate student, Dartmouth

Locale of the investigations which prompted this paper is 80 percent covered by ice. The higher beaches where the work centred rise in some cases to 100 meters above sea level and are comprised, for the most part, of reworked till. The beaches are well preserved and are the dominant feature of the landscape.

Dated samples were all imbedded in the beaches and were therefore deposited by natural means when the beaches were forming. They were not lying on the surface where they could have been carried by waves, wind or man and therefore give a good maximum age of their surroundings.

The study of several samples indicated that the

SOUTH PERMAFROST LIMIT SOUGHT

beaches studied were in the process of formation between 8,000 and 10,000 years ago. Pummice samples were correlated with finds in Norway and in Denmark.

Two samples of whale bone were dated as a check on the pummice samples, and particular emphasis was placed on the inorganic fractions due to a higher degree of deterioration in the organic matter. Dates were also obtained from shell samples found on the various beaches. Both outer and inner parts of the shells were dated and in all but one of the 10 samples, the outer part was found to be younger. Since the outer part is obviously more subject to contamination, only measurements from the inner parts were accepted.

Strictly speaking, it is impossible to say with absolute certainty that all—or any—of the shells are in situ because in most areas they are found where frost action has pushed plugs of till up through the beach shingle or in extensive flat areas where beach shingle is lacking. The valves are rarely joined together and never occurred in living position. No shells in the 9,000 to 10,000-year range were found above 44 meters.

In substantiating the dates, the author deduces the shells are truly in situ because of their great abundance and expresses the belief that the figures are correct.

The dates obtained for bone, driftwood and shells may be plotted on a time-elevation diagram and the resulting curve shows the expectable course of land updrift for the past 10,000 years; a progressively slower rate of updrift over the passage of time. Shell ages of from 35,000 to 40,000 years cannot be fitted into this scheme. Evidence indicates that even though the ice was much heavier in the area 25,000 or 35,000 years ago, it was not heavy enough to destroy the beaches.

Maximum glaciation was probably pre-40,000 years ago. No high terraces in the glacial age are known.

★ ★ ★

PERMAFROST INVESTIGATIONS IN CANADA

By R. LEGGET
Director, Division of Building Research
National Research Council

Permafrost is a term widely misused in Canada, when applied to a description of ground conditions when its temperature is 32 degrees F or below, since all of Arctic Canada is underlain by ground in this condition.

Scientists having an interest in the geo-thermal properties of the earth in the far north must—sooner or later, come to grips with the special properties of permafrost.

Builders also find themselves forced to deal with permafrost since, in many areas, the frozen ground consists of saturated silt. In a case such as this, permafrost is no longer a mere scientific curiosity but a practical problem of great importance.

Follow Russia's Lead

The author stressed that much of the work being done by Canadian scientists is a duplication of earlier efforts in Soviet Russia and particular note was made of the value of Russian literature in permafrost investigations.

"At the beginning," he declared, "I want to ma
quite clear that we are the amateurs. We are m
following in the footsteps of other workers in Russia
to a lesser extent, in Alaska."

Permafrost investigators have subdivided the
into two basic problem areas. One is that of deep pe
frost in the far north where it extends to depths of
meters, while the other deals with the southern limi
permafrost.

Location of this southern limit is of prime im
ance in the development of Canada's north since pe
frost—or lack of it—must be taken into account
building air strips, roads or structures of any kind.
work of delineating this southern boundary on su
maps is now in progress.

Temperatures Important

Temperatures provide a good index of permafrost
ditions. These readings are subjected to daily cy
variations at the surface of the ground and annual
tions at deeper points. Mean ground temperature
change over a given period of years only to the e
that the heat losses and gains for that period are
equal; the difference being inevitably reflected in
changes in heat level stored in the ground. It fo
that a permafrost condition may be developed ov
very long period of time due to a small imbalanc
the heat gains or losses at the surface and corresp
ingly a permafrost condition may be destroyed in a
short period if there is created a relatively large
parity between heat losses and gains. It follows, t
fore that close attention must be paid to the fa
which cause these losses and gains of heat.

Climate Factors

These factors may be grouped broadly into "Cli
and Terrain", with the latter including geo-thermal
erties. The interaction between radiation from
space and the earth's surface and atmosphere pro
the climate and this in turn affects the energy exch
at the surface of the earth itself.

It has been suggested that the southern perma
limit corresponds with a climatic condition at the e
surface where the mean temperature is freezing or
but this theory is not suitable—at least—for Can
conditions because areas of sporadic permafrost have
found south of the 32-degree isotherm. In Manitob
instance, the southern permafrost boundary cuts di
ally from the 25-degree isotherm to the 30-degree
therm. It would therefore appear that there is
connection in Canada between mean annual tempera
across the country and the southern boundary of p
frost. Hence, prediction of permafrost conditions c
be based upon climate factors.

Heat Exchange Key

The question must, therefore, be based upon a
of heat exchanges. Short wave solar radiation rec
at the earth's surface is broken up into a numb
components, each causing a process in which heat tr
occurs. Some is reflected from the ground's surface
amount dependent on the reflectivity of the surface;
creates convection in the air resulting in turbulent

STUDIES OF OCEAN FLOOR LAUNCHED

ge; some is used for evapo-transpiration, and the der heats the ground.

at is also carried into the ground by rain and water. Surface enters the picture as a further cation when it is remembered that the earth s heat during the day from solar radiation and tes it during darkness to a degree depending upon aterial of the surface. Angle of incidence of the ays and cloud cover also enter into the problem.

Broad Relationship

oming solar radiation and permafrost distribution lated on a broad scale. The relationship is so l, however, it appears to be of little use in deter- ; the limit of permafrost's southerly penetration.

at exchange at the surface of the ground may be sed in this way; the total annual radiation balance al to the heat involved in evaporation-condensation he heat involved in conduction-convection. Hence othermal properties of the ground must be con- l when seeking the southern extremity of perma-

ater surfaces and the reflection therefrom are factors must be considered, as are the reflections from covered ground or ice and the properties of the l itself.

★ ★ ★

IIC STUDIES OF THE ARCTIC OCEAN FLOOR

By K. HUNKINS

Lamont Geological Observatory, U.S.A.

is paper deals with seismic reflection and refrac- tudies of the Arctic Ocean floor conducted with an ,000 B type seismograph identical with units used the IGY in the Antarctic. Geophones were placed ice for signal detection but, in a few cases, hydro- s were used in the water and microphones for air .

eflection patterns from the ocean floor were obtained ooting half-pound blocks of TNT on the ice and g up vertical reflection from the ocean floor. Both s and sub-bottom reflections were obtained from records, giving some indication of the sediment or stratigraphy below the ocean floor.

Ice Floe Base

he observation station was built on an ice floe which d at about 3½ miles a day and two shots were taken g every 24-hour period. A total of 623 soundings obtained during the time the station drifted and of these were available for sub-bottom data.

he area traversed by the floe included the Arctic rise, is a broad feature extending from north of Elles- Island off the edge of the shelf over to north of le Island. Since the entire journey was over this re it was possible to delineate it with a reasonable e of accuracy. Soundings from the station, besides ding depths, indicated the dip and strike of the floor in the same way as do prospecting reflections.

he dip of the ocean floor was found to vary from degrees to a maximum of 22 degrees.

he rise appears to be a broad, well-defined feature 100 kilometers in width. General topography is irregular and may be referred to as a rugged, "hill-and-valley" region.

Good Reflections

In studying the sub-bottom, the author reported particular success with reflections which indicated sediments to a depth of about one kilometer beneath the ocean floor. There appeared to be a distinct difference between the eastern and the western part of the Alpha rise, and indications were present to indicate some considerable variation in topography on either side of the rise.

Three short, unreversed refraction profiles were obtained. One of these covered a traverse about 11 kilometers long with the interpretation showing 1,800 meters of water, 290 meters of low-velocity sediment underlain by a 4.7 kilometer layer which is referred to as a consolidated sedimentary layer 2.8 kilometers thick. Below that lay the oceanic layer with a 6.44 kilometer per-second velocity about five kilometers below the ocean floor.

From the evidence gathered, it appears that the seismic velocity structure in this portion of the Arctic Ocean closely resembles that found in the North Atlantic Ocean on similar structures as recorded by various scientists.

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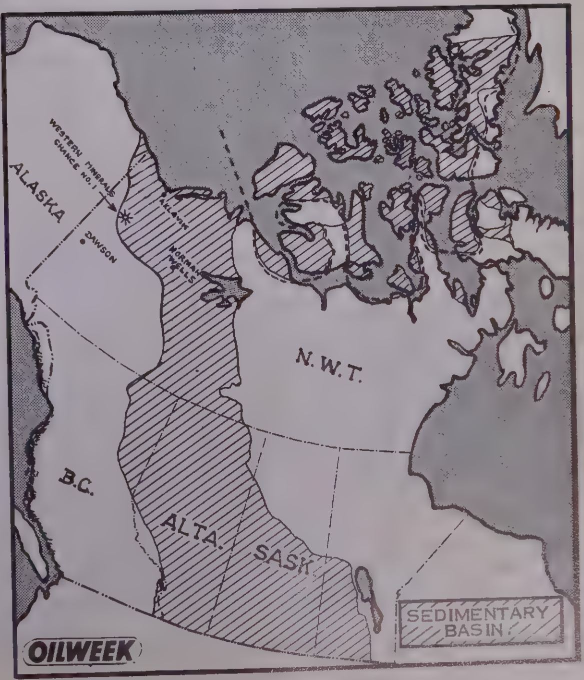
GEOPHYSICAL STUDIES ON IGY DRIFTING STATION BRAVO 1958-59

By DONALD PLOUFF, USGS

The studies outlined herein were undertaken during 1958 and 1959 by the author and other members of the



CONTINENTAL SHELF DELINEATED

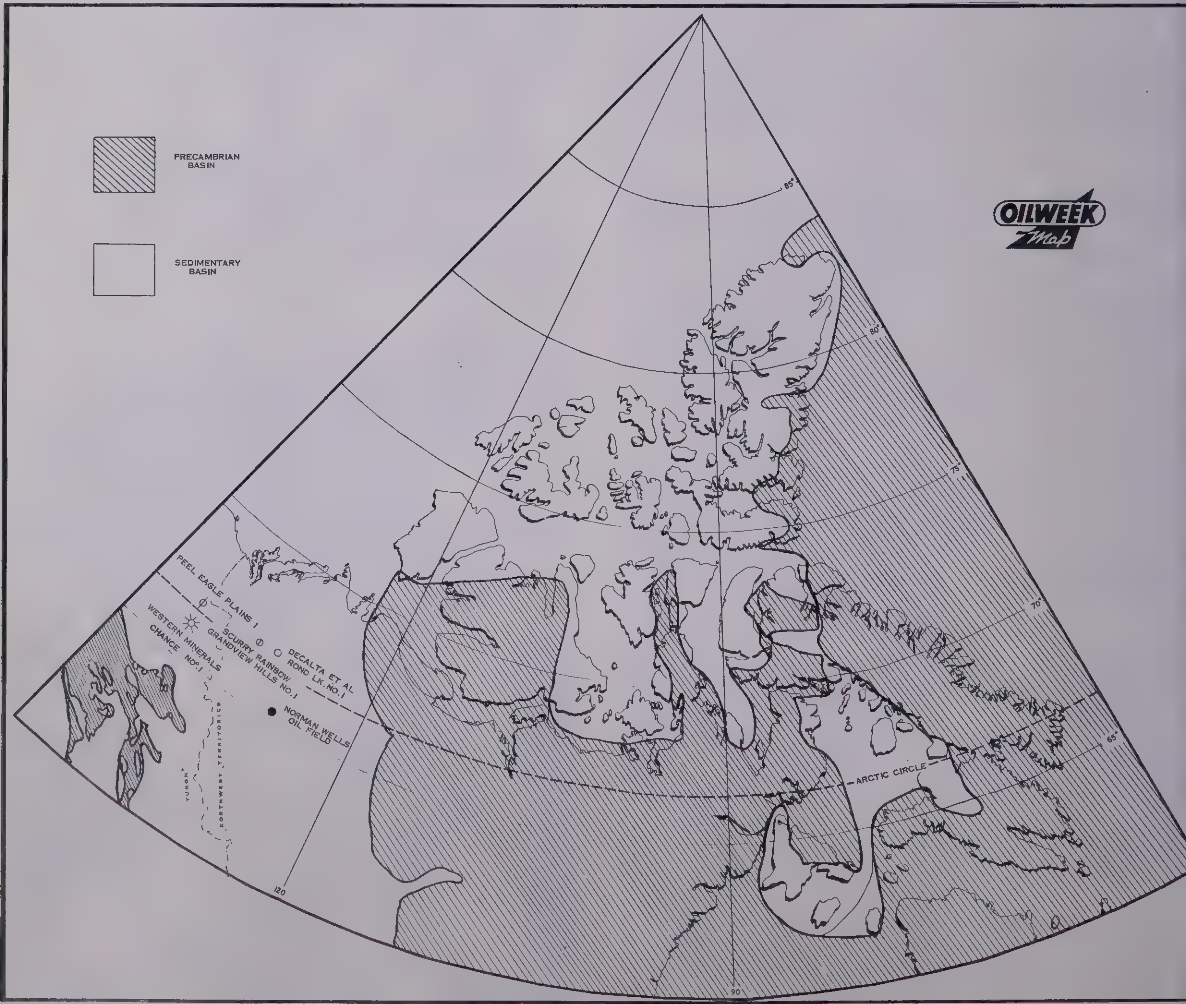
United States Geological Survey in co-operation with the Cambridge research centre. Measurements were made over a traverse of more than a thousand miles southwest of the Canadian coast.

Reflection measurements were made to determine ocean bottom depths and sound velocities through sea water were obtained from empirical tables. Depths measured varied all the way from 200 meters to 2,400 meters as the ice platform floated almost parallel to the continental shelf. Areas covered by the geophone spreads were from 6,500 to 180,000 square meters. Ocean bottom dip in the area measured two degrees on the average and only 42 out of 221 dip measurements exceeded three degrees and none exceeded nine degrees.

In making the measurements, the geophones were located on from 3½ to 5½ meters of pack ice using charges ranging from .2 to 1.4 kilograms of TN
shot depths of one meter in ice to 35 meters in sea v

Sub-bottom reflections were observed on many se
records, however, the number and quality of recor
varied from day to day along the path of the floe's jo
and correlation is somewhat difficult.

Electro-resistivity measurements were made with
tro-separations great enough to assure penetration of
trical current to the ocean bottom. Resistivity distrib
vertically through the ocean was determined by el
logging so that the effect of sea water could be rem
from resistivity data taken on the horizontal spread.
cause of the high-conductivity characteristics of sea
large electro-separations must be used to measure
tivity of the ocean bottom. A total of 20 resistivity s
ings was recorded during the summer.



SEDIMENTARY AREAS — The above map graphically portrays the sedimentary areas of the Arctic archipelago and the Arctic coast, wh
attention of the symposium was focused.

"WHOLE - WORLD" CONCEPT DEFINED

FORMER MOUNTAIN CONNECTIONS IN THE ARCTIC

By J. TUZO WILSON
University of Toronto

he world can now be studied as a whole; it must naving in some systematic pattern, and an investiga- nd comparison of the various parts of the world ter would do much to illuminate our local problems."

his was the concept advanced by Dr. Wilson during pening session of the symposium in his paper on r mountain connections in the Arctic. He claimed his concept needs "to be introduced into our geo- l thinking to a very much greater extent."

r. Wilson stated that in geological studies, "mapping is not the whole story," and that a very much er point of view is required.

Greater Viewpoint

ne fact that we are now able to map two-thirds e world covered by water provides us with a much er point of view and could "change our thinking e earth very much." We can now compare the e with other continental areas and the interior, open- a new era in geology."

he author claimed that we can now "begin to ibe the earth as a whole."

e described as an enigma the fact that "we have r atomic and stellar theories than we have know- of how the earth works, seeing that we cannot he atoms or touch the planets."

e said that the earth likely operates according to known physical and chemical laws, rather than ding to new and undiscovered laws, but the appli- ns of the laws which govern the way the earth s "are not understood and are very difficult." He osed that geologists and scientists should endeavour nd the applications of these laws.

nasmuch as the earth appears to work in a universal ner, Dr. Wilson claimed that a study of comparative ogy throughout the world, "which we are now be- ng to understand, offers an important means of king the problem."

Ie traced patterns of continuous mountain trends h extend across the earth, pointing out the common acteristics of these trends and their points of con- ons such as at Gibraltar and Antarctica.

The paper suggested that the mountain ranges in Canadian Arctic Islands extend under the Arctic an to connect with the mountain systems in Alaska form a continuous trend with the Caledonian Her- an and Ural mountains.

* * *

DEVONIAN STRATIGRAPHY, ENTRAL MACKENZIE RIVER REGION, NWT

By H. G. BASSETT
Shell Oil Company of Canada

Dr. Bassett reviewed the stratigraphic work carried in the past by geologists working in the Northwest Territories, describing the formations which had been classified and named.

The Bear Rock formation is the oldest formation of the Devonian system in the Northwest Territories, exposed at Great Bear River, re-defined by Hume and Link in 1945.

To the east along the Pre-Cambrian shield the Bear Rock beds comprise anhydrite evaporites, extending from the Arctic Ocean south into Alberta where they are called the Chinchaga formation. In the central Mackenzie Valley the Bear Rock beds are composed of combonate brecha, varying from 400 to 500 feet thick in the Norman Wells area to about 900 feet in the southern Franklin Mountains. West of the Mackenzie River Valley and the Mackenzie mountains it is composed predominately of bedded carbonates. They range up to 6,500 feet in thickness in the Upped Redstone locality.

Overlying the bedded carbonates in many of the western areas of the NWT are fossiliferous Lower Middle Devonian limestones.

Overlying the Bear Rock in the vicinity of Hume River is a sequence of limestones varying from 300 feet thick in this area to 450 feet in the vicinity of Norman Wells.

These beds, described as the Hume formation in honor of Dr. G. S. Hume, correlate to the Rampart beds, according to the author.

These beds can be traced as far north as the Arctic Ocean near the mouth of the Anderson River, and south into the Summit Lake area of northern British Columbia, and are correlated to about the lower two-thirds of the Pine Point formation at Great Slave Lake.

Overlying the Hume formation is the Hare Indian formation, a greenish-gray calcareous shale, which is sometime bituminous. Thickness varies from 500 to 600 feet. It has been traced north to the Anderson River on the Arctic coast and south to the Fort Simpson area. At Norman Wells it has been referred to as the Lower Fort Creek Shales, according to Dr. Bassett.

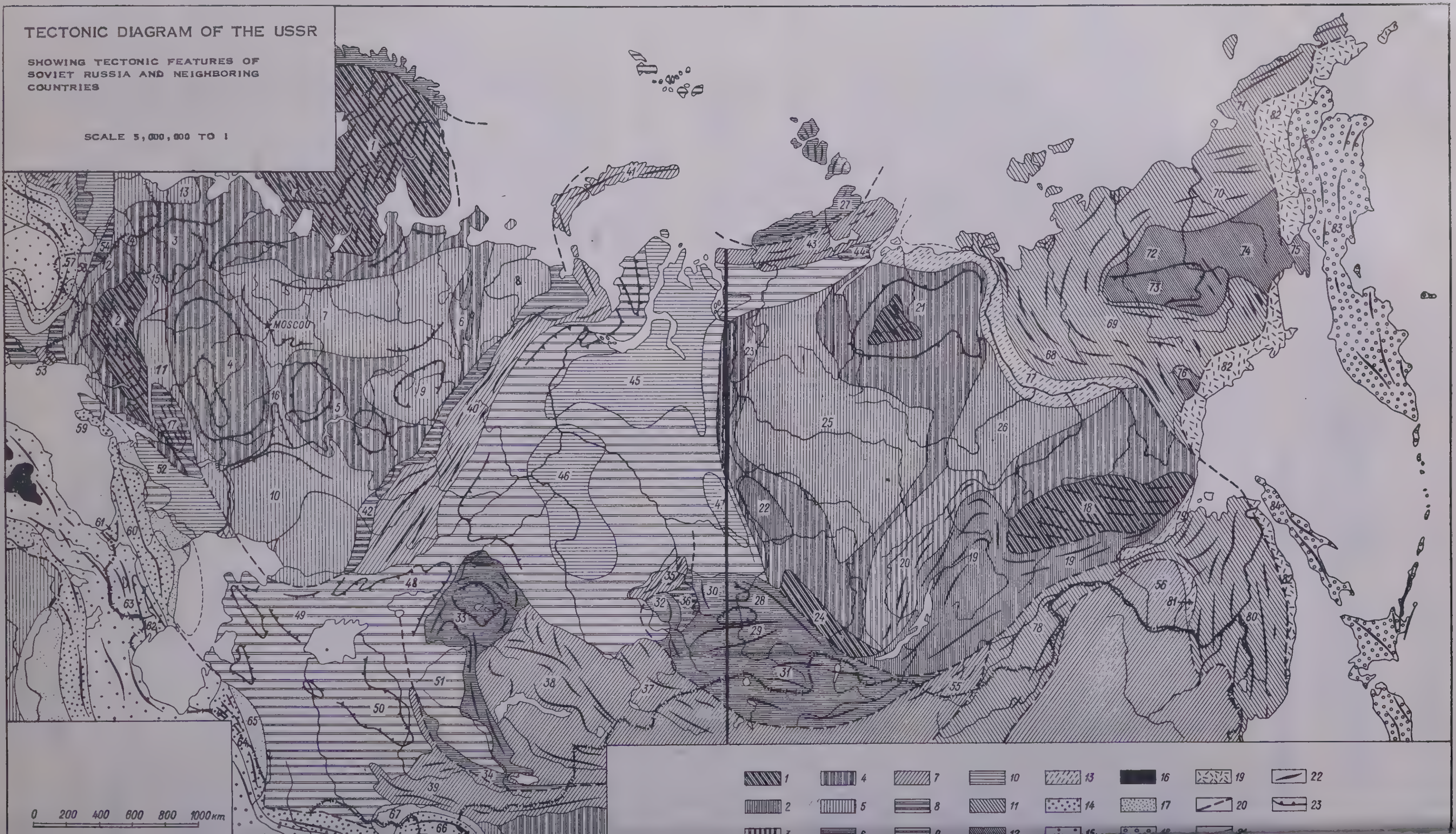
Producing Formation

Overlooking the Hare Indian is the Kee Scarp formation, the producing limestone formation at Norman Wells. The lower portion is composed of bedded limestones, while the upper part is partially reef. Thickness ranges up to 800 feet. The platform part of the Kee Scarp can be correlated to the Presquelle formation while the upper beds may be the same as the Slave Point in the opinion of the author.

Overlying the Kee Scarp is the Canol formation, composed of black, general non-calcareous shale.

Overlying the Canol formation is the Imperial forma-

TECTONIC FEATURES OF NORTHERN RUSSIA



TECTONIC DIAGRAM OF THE USSR

SHOWING TECTONIC FEATURES OF SOVIET RUSSIA AND NEIGHBORING COUNTRIES

SCALE 5,000,000 TO 1

SOVIET RUSSIA'S GEOLOGY DETAILED

ı sequence of fine claustics, shales, silstones and d sandstone.

e author recommended that the names "Ramparts" Beavertail" be discontinued, and that the reviewed ions of Bear Rock, Hume, Hare Indian, Kee Scarp, and Imperial be adopted for an ascending sequence vonian stratigraphic units.

★ ★ ★

MAIN FEATURES OF THE TECTONIC LOPMENT OF THE CENTRAL SOVIET ARCTIC

by I. P. ATLASOV and V. N. SOKOLOV

Arctic Institute of Geology, Leningrad

his paper outlines the tectonic development of the l Soviet Arctic. The following structures are situ- n this area: the east Siberian platform, the west Epi- nian Siberian platform, and the fold systems of the Verkhoyanks mountain areas, forming a northern semicicle around both platforms.

GENERALIZED TECTONIC MAP

By N. S. SHATSKY and A. A. BOGDANOV

Legend of the symbols (1-23)

-Cambrian Platforms
Outcrops of Archean and Proterozoic basement complex (shields)
Outcrops of Baikal folded complex
Angara-Lena downwarp (marginal geosyncline)
Areas of shallow buried basement (Subsurface flanks of shields and "anticleases")
Areas of deep buried basement ("syncleases")
eas of Paleozoic Folds
Shallow buried Caledonian orogeny folded complex, and zones of earlier metamorphism of Hercynian orogeny
Shallow buried Hercynian folds
. Downwarps of Hercynian orogeny
. Region of comparatively shallow buried Paleozoic basement in areas of epihercynian platform
. Region of deeply buried Paleozoic basement in areas of epihercynian platform
eas of Mesozoic Folds
. Shallow buried folds
. Intermediate buried folds
. Downwarps
eas of Cenozoic Folds of Tethys
. Outcropping anticlinoria
. Buried anticlinoria and downwarps
. Intermediate buried massifs
. Downwarps
eas of Cenozoic Folds of Pacific Belt
. Outcropping folds
). Volcanic complex of outside belt
ructural Symbols
). Limits of geosynclines of different tectonic periods
.. Spread of folded structures
2. Anticlines and anticlinoria
3. Outlines of downwarps, syncleases, and anticleases

The examination of the geological structures of this part of the earth provides a division of its history into seven main geo-tectonic periods: Archean, Proterozoic, Sinian, Lower Middle Paleozoic, the Upper Paleozoic-Lower Mezozoic.

A large geosyncline formerly covered the entire area during Archean time, and prior to a postulated deep subsidence of the basin and an intensive removal of clastic material from the area. A period of folding completed the Archean geotectonic period.

Platform Structure

During the second half of the Proterozoic period, a platform structure existed in the central part of the Central Siberian Platform, which extend to the south of the Arctic Circle and a system of geosynclinal zones framing it on the northeast, north and west. In the Siberian highland there existed a region of tectonic movements of platform type north of the Arctic Circle.

During the Sinian period, nearly the whole of the area represented a platform with sub-geosynclinal character. Deposits of up to 2,000 meters were laid during this period.

The Lower-Middle Paleozoic period corresponds to a time interval from the Lower Cambrian to the Lower Carboniferous. Two episodes of structure development characterized this period: the Lower Paleozoic and the Middle Paleozoic.

During the Sinian and more particularly the Lower-Middle Paleozoic periods, the platform which had originated in the Proterozoic spread progressively until it occupied nearly the whole area to the east of the Urals.

Two Episodes

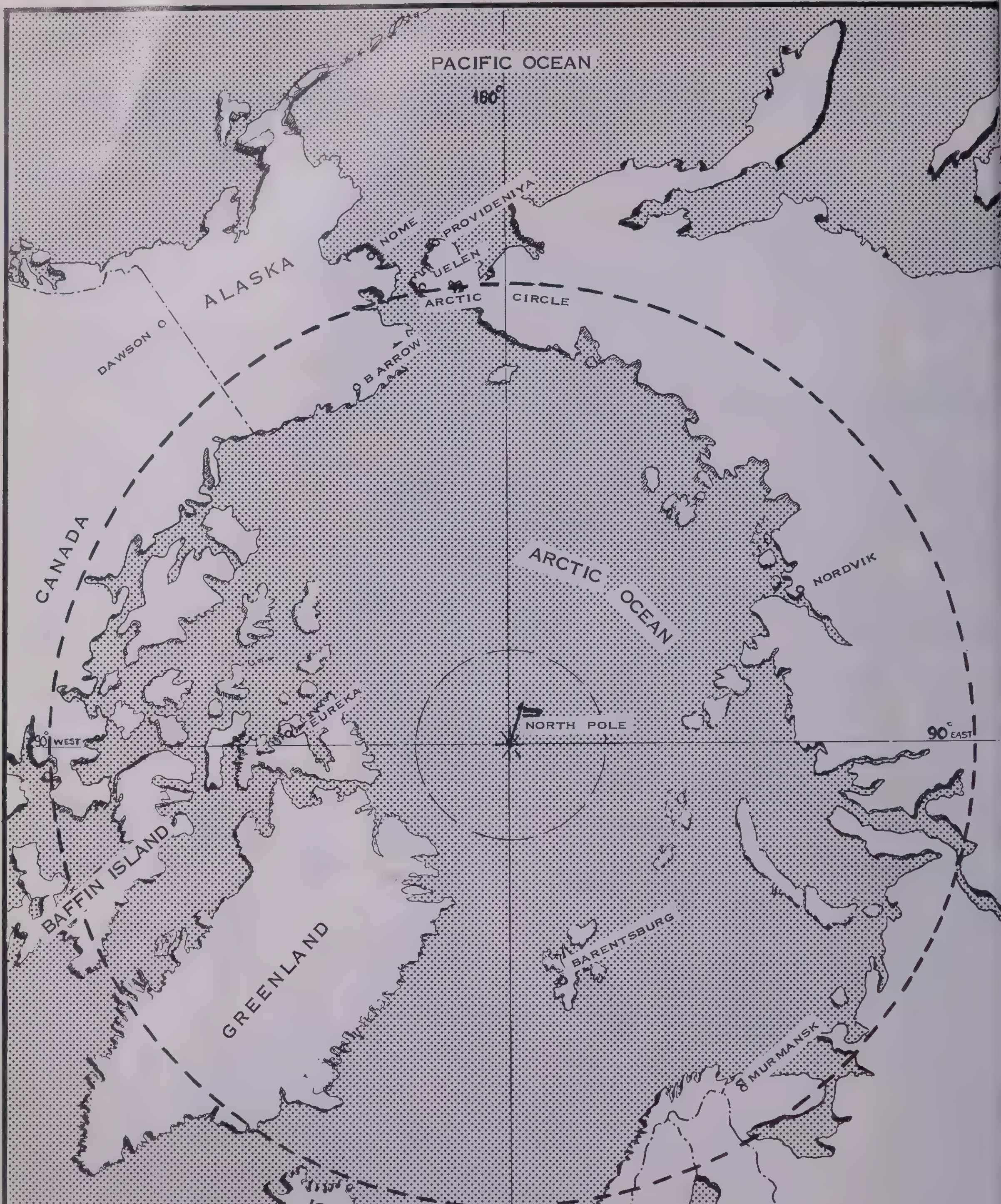
The Upper Paleozoic and Lower Mesozoic tectonic period began for most of the territory in the Middle Carboniferous, and was completed by the end of the Triassic, or at the beginning of the Jurassic. As in the previous period, formation of structures took place mainly in two episodes. On the whole, the period is characterized by a considerable expansion of areas with a geosynclinal character of tectonic movement. This period was marked by the development of the Taimyr and Verkhoyansk geosynclines. In the Urals-Novaya Zemlya areas, the geosyncline existed till the end of the Paleozoic.

The Meso-Kainozoic tectonic period began in the Jurassic and ended in different localities between the end of the Cretaceous and the end of the Paleogene. This tectonic period was characterized by a new expansion of the platform at the expense of the Tairmyr geosyncline, and in the Cenozoic the whole area represented a platform.

As a result of the tectonic indenudation processes which took place during these seven main geotectonic periods, the modern structure of the central Soviet Arctic has taken shape. The main features of the tectonic development are recurrent changes of the tectonic pattern and erosian processes at the end of each tectonic period and of each phase of its development.

Regions Outlined

The following tectonic regions can be distinguishe


PACIFIC OCEAN
180°
NOME
PROVIDENIYA
UELEN
ARCTIC CIRCLE
ALASKA
DAWSON
BARROW
CANADA
ARCTIC OCEAN
NORDVIK
EUREKA
NORTH POLE
90° WEST
90° EAST
BAFFIN ISLAND
GREENLAND
BARENTSBURG
MURMANSK
ICELAND
NORWAY
SWEDEN
OSLO
STOCKHOLM
ATLANTIC OCEAN
0°
GREAT BRITAIN
OILWEEK

modern structure of the region: (1) The mesozoic yansk-Chukotskaya folded area consisting of the lesozoic Verkhoyansk and the Mesozoic-Cenozoic orisk folded system and composed of six struc- ages. (2) The Early Mesozoic Taimyra-Novaya folded area which has six or seven structural (3) the Late Paleozoic Ural Novaya Zemlya folded aracterized by five structural stages; (4) the Late ic Lerna-Enisey trough with two structural stages; northern part of the West-Siberian Epi-Hercynian n, which has three structural stages, and (6) the n part of the Pre-Cambrian East Siberian platform, ing of six structural stages.

zones both in geosynclines and in the platform sely related with the basement faults, which served ling channels for magmas and hydrothermal solu-

the platforms and in the Lena-Enisey trough in periods of tectonic development the conditions atures favorable for oil and gas formations were t. Oil and gas shows have been established in the and the Lower-Middle Paleozoic structural stages Siberian platform, and in the Upper Paleozoic Mesozoic, and in the Mesozoic-Cenozoic structural in the Lena-Enisey trough, and on the West an platform.

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GEOLOGICAL INTERPRETATION OF AEROMAGNETIC PROFILES FROM THE CANADIAN ARCTIC

F. GREGORY, M. E. BOWER and L. W. MORLEY
Geological Survey of Canada

Aeromagnetometer surveys will provide useful data e geological study" of the Canadian Arctic, accord- the authors.

heir paper reviews the results of an airborne geo- cal survey conducted in the Arctic Archipelago in by the GSC in conjunction with Operation Franklin. al of 9,000 lines miles of widely spaced profiles were in a cobweb pattern centred at the base of opera- at Resolute Bay on Cornwallis Island.

Data Recorded

he flights were conducted between June 14 and 2 at a height of 800 feet and a speed of 120 mph. survey recorded the following data: the total mag- field, the total gamma radio activity, the terrain ance, and a positioning film strip.

light lines were laid out so as to traverse the main ogical regions of the Archipelago and continuous netic recordings were obtained along them. The lting profiles showed a general correlation with the rent geological regions. Calculated depths to base- t were in excess of 10,000 feet.

The authors report that magnetic anomalies which rofile show a control minimum with marginal maxima characteristic of known gypsum domes in the area. form magnetic expressions result from sills in the ta which are variously upturned intrusion of the domes.

Observations Confirmed

The regional interpretation of the geophysical data, rding to the paper, substantiates the general geological ctures recognized by field geologists and provides itional detail.

By combining interpretations of the geophysical data h known geological conditions of the area, the authors cluded that the Boothia Arch appears to be an imperfectly developed horst extending at depth as far north as the southeast corner of Bathurst Island. Related basement uplifts may underlie the southern portion of the Cornwallis Fold Belt. Several of the lower Paleozoic basins may occupy, in part, graben or fault block structures.

A west-trending regional fault in Lancaster Sound appears to parallel the south coast of Devon Island and may offset the northern end of the Boothia Arch. The magnetic data from the Sverdrup Basin suggest that igneous dyke activity and extensive folding occur only within the eastern half of this basin, although sheets of basic rock are probably present in much of the western half. A structural complex similar to the Parry Islands and Central Ellesmere Fold Belts may bound the basin on its northwest side.

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GYPSUM DOME TECTONICS

by E. H. KRANCK
McGill University, Toronto

The large gypsum piercement domes of the Canadian Arctic Archipelago—responsible for much of the high hopes of large oil reserves in the area—were studied by a McGill University expedition to Axel Heidberg Island in the summer of 1959.

Professor Kranck reported that the purpose of the expedition was to develop interest in a deep study of the island on a broad base. The small expedition of last summer will be followed this summer by a 20-man party which will study glaciology, permafrost, geomorphology, geology and geophysics.

Much Gypsum

He reported that the island has "enormous quantities" of gypsum which is "probably better exposed than anywhere else in the world," and there are between 30 and 40 gypsum domes within a relatively small area.

The structure of the central part of the island is characterized by a number of anticlines and synclines, fairly regular but affected by the gypsum piercement along the anticlines. He reported that the synclines are broad and the anticlines are narrow.

Big Dome Found

He reported that one of the largest domes on the island has a diameter of "around six miles." The mechanics of the tectonics is essentially a peninsula depression, he reported, combined with an isostatic pressure from below.

He concluded that Axel Heidberg Island offers some excellent opportunities for detailed studies on the formation of gypsum domes.

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THE CANADIAN POLAR CONTINENTAL SHELF PROJECT

By E. F. ROOTS

Department of Mines and Technical Surveys, Ottawa

The Canadian Polar Continental Shelf Project has been organized by the Department of Mines and Technical Surveys to carry out a broad research program embracing oceanography, hydrography, submarine and terrestial geology, geophysics, glaciology, biology and logistics, according to Dr. Roots. In the geophysical studies, particular attention will be paid to seismic, gravity and magnetic work.

The author commented on the urgent need for oceanographic knowledge as well as a knowledge of the mineral potential of the continental shelf.

Organized as an independent administrative unit, the program will be carried out in close conjunction with other government and industry scientific research programs. By combining a wide range of studies, it is hoped to overcome the problem of logistic which often overwhelms individual research projects, and to develop "team-thinking" of the various specialists involved.

Work Concentrated

During the first season that the project has been in operation, work was concentrated on two areas—the central part of the Arctic continental shelf, and north of Hudson's Bay.

The field group working in the central edge of the shelf employed a total of 19 men carrying out reconnaissance and preliminary work from early March until mid-October.

Work by this party was concentrated on two problems: (1) determining a method of fixing position in an area where there are no landmarks, where the sky is overcast 80 percent of the time, where the sea is covered by an almost continuous ice pack, and where radio communication is poor; and (2) the transportation problem.

Fixing position proved to be a "real problem," according to the others, and was finally accomplished by high-power, low-frequency electronic system. In order to establish a new position-fixing system the group has to obtain information on the speed of radio waves over varying conditions of sea-ice—sometimes solid and sometimes with open water patches—as well as information on current activity of permafrost. After measuring these conditions the group was able to devise a portable electronic survey system which enables them to plot their positions with accuracy at distances of up to 600 miles off the coast.

Oceanographic stations were established on a trial basis in the Price Gustav Adolph Sea, gravity and magnetic studies were made and some key points in the area were tied into the regional gravity net, a few short cores were taken from the ocean bottom, and a start was made on glaciology studies of an ice cap in the area.

Limited Areas Studied

The second party, working in the Fox Basin area, completed a thorough oceanographic study of a limited area, delineating the interchange of water coming through the Arctic Archipelago from the Arctic Ocean to the Atlantic and in and out of Hudson's Bay. Some bottom samples were also taken. Use made of the ice-breaker Labrador during September and October.

During 1960 the group plans to carry out main traverses from the Arctic Islands in a northwest direction some 500 to 600 kilometers across the continental shelf, hoping to reach the continental slope. Systematic soundings will be taken along these traverses, oceanographic observations will be made and bottom samples will be taken. Reflection and refraction seismic work will be made from shore out across the shelf and if possible across the channels between the islands, in an attempt to determine the structures in this area. Gravity and magnetic studies will keep pace with this program.

Geological work will include sedimentation studies, studies of the characters of the slope of the channels, geochemical studies and an investigation of the heat flow from the ocean floor, from the permafrost area and from the areas near the ice caps.

Dr. Roots said that the project may be able to
at a comprehensive picture of the recent geological
of the area by integrated work on the part of the
graphers, physiographers, botanists and by
meteorological studies.

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THE PALEOZOIC OF THE SOVIET ARCTI

By F. G. MARKOV and B. V. TKACHENKO

1. Paleozoic deposits compose the mantles of the
sian and the Siberian platforms and the adjacent
donian and Hercynian folded areas, and partly for
basement of the Mesozoic-Cenozoic structures o
North-East USSR.

2. The discussion on the lower contact of the Pale
rocks is not over as yet. The Sinian complex is not p
to belong to the Paleozoic. On the Taimyr an
northern margin of the Central Siberian Plateau Cam
deposits rest unconformably on Sinian rocks, sharply
arated from the latter by their mineral compositio
by fossils.

3. Complete sections of Cambrian strata repres
mostly by carbonate rocks are known in North-C
Siberia. These rocks may be divided into bios
graphic zones. West of this is a region of contin
deposits and volcanic activity, while to the east we
an area of calcareous continental deposits. The
down of these formations is limited to series. Some
the Cambrian rocks contain bitumen.

4. The same depositional environment persisted
the Ordovician, but in the Urals-Novaya Zemlya an
Grampian geosynclines there was an increase in
matic activity. The Ordovician deposits can be di
into the European stages. For the Middle Siberia a
arate system of stages has been worked out.

5. The Siberian deposits represented predomin
by carbonate facies, are found on the continent ea
the Timan mountain range and also on the No
Zemlya, the Severnaya Zemlya and the Novosi
Islands. These strata may be divided into series
stages. Magmatic activity took place in the Polar

6. The Devonian beds were deposited under ra
changing depositional conditions caused by the
donian orogeny. On the Kol'skiy Peninsula only
Devonian continental formations have been reve
East of the Timan-Kanin Range and on the large is
the deposits of three Devonian series subdivided
stages are developed. The marine carbonate-terrige
strata have been changed by hydrochemical substa
sometimes with the accumulation of salts and bitu
Magmatic activity took place everywhere.

7. The Carboniferous deposits are mostly represe
by carbonate rocks of the Lower Series which are
veloped on Novaya Zemlya, the Novosibirsk Islands
on the continent east of the White Sea. Tournai
Visean and more rarely Namurian deposits are di
guished. Middle and Upper Carboniferous deposits
predominantly continental deposits with poorly prese
fossils, a fact which makes them similar to the hi
Permian beds. Magmatic activity took place on
Kol'skiy Peninsula and on the Novaya Zemlya.

8. Permian deposits are widespread over the w
region extending from the White Sea up to the Be
Sea and on Novaya Zemlya. The thick continental s
are often coal-bearing and sometimes oil-bearing.
Lower and the Upper Series and more rarely the st
are recognized. The division into formations is

ised. During the Permian period the Pechora, and Tungusska coal-bearing basins were formed.

* * *

PRE-CAMBRIAN OF THE SOVIET ARCTIC

By M. I. RABKIN and M. G. RAVICH

he Pre-Cambrian deposits are situated in areas fferent structural features. The Archean forma- e developed in the northern part of the Siberian n (the Aanabar Massif) and on the Baltic Shield y Peninsula); the Proterozoic deposits occur in lded in Paleozoic time (the Taimyr Peninsula, the ya Zemlya, the Polar Urals) and in Mesozoic hukotskly Peninsula, etc.).

The Anabar Massif consists of different hypers- earing gneisses and crystalline schists often mig- l, paragneisses, marbles and quartzites. This lage is divided into four conformable series of anulite and amphibolite facies. Intrusions are re- to two tectono-magmatic cycles: (1) the Archean with four phases, which is mostly represented by ic granites, and (II) the Lower Proterozoic cycle osites).

The Archean of the Kol'skiy Peninsula is divided he Belomorsk and the Kol'sk series. Paragneisses ominant in the Belomorsk formation; the Kol'sk tion consists of various gneisses, including the es rich in alumina. The Proterozoic is divided into series of sedimentary and volcanic origin. The an intrusions are represented by an earlier phase and ultrabasic rocks, oligoclase gneissic granites) y a later phase (drusites and microcline gneissic tes). The Proterozoic igneous rocks involve ultra- and basic intrusions and microcline granites.

. The Pre-Cambrian of Taimyr-Severnaya Zemlya is divided into the Lower and the Upper Proterozoic. Lower is represented by a thick assemblage (7-8 km) lagio-gneisses and crystalline schists partly magmat- and formed mostly at the expense of terrigenous de- s under conditions of the amphibolite facies. The er Proterozoic assemblage (6-7 km thick) consists of nschists, phyllites, marbles and metamorphosed sand- es which were formed partly of sediments and partly asic lavas under the greenschist conditions. Metamor- ed ophiolites and orthoamphibolites occur among the Cambrian assemblages. The Proterozoic granite rocks epresented by three groups; the porphyroblastic ultra- amorphic granite rocks, the two-mica and the granu- l granite rocks.

5. In the Polar Urals the Proterozoic formation with iss, schist and the amphibolite members has been dis- uished. The first two members have a sedimentary in, the third one has a volcanic origin.

6. On the Chukotskiy Peninsula there is an undivided iss assemblage, overlain uncomformably by Lower Si- an limestones. The Pre-Cambrian age is determined analogy with the Seward Peninsula (Alaska). Biotite gio-gneisses and crystalline chists of the amphibolite ies are dominant in this assemblage. In its basal part re are marbles. Gneissic granites and related mig- tites are widespread.

7. The regions above differ sharply by their character. wever, they have much in common. Intensive erosion l sedimentation in extensive areas is typical of them. en in the Lower Archean there were extensive geosyn- nes and vast land spaces subjected to erosion.

THE MESOZOIC AND THE CENOZOIC OF THE SOVIET ARCTIC

By V. N. SACHS and S. A. STRELKOV

On the Soviet Arctic territory Mesozoic and Quarternary deposits are widely developed; Neogene and Paleogene deposits are met only sporadically. Marine facies of Triassic deposits are known east of the Hatanga meridian and on the Franz Joseph Land, all the stages being distinguished including the conventional Rhaetian.

The Lower Triassic is divided into two stages: the Indus and the Olenek. The continental and lagoonal Triassic facies are widespread in the northern part of the Russian Plain, on the Franz Joseph Land and in the northern part of Middle Siberia. The last area is notable for an important role of volcanic rocks in the Lower Triassic. The Jurassic predominantly marine deposits are divided into series, stages and, partly, into sub-stages.

The basal stages of the Lower Jurassic are revealed in the North-East Siberia.

Since the Domerian the marine facies expanded towards the northern part of central Siberia and since the Aalenian towards Franz Joseph Land. During the upper part of the Middle Jurassic and lower part of Upper Jurassic the marine facies expanded towards the northern part of West Siberia and Russian Plain.

The lower horizons of Cretaceous strata are also widespread but since the Hauterivian the development of marine facies has been considerably reduced and continental and lagoonal formations begin to predominate.

The marine sediments of the upper half of the Lower Cretaceous and Upper Cretaceous strata have remained in the northern part of West Siberia and along the coast of Bering Sea. The Cretaceous deposits in northeast Siberia also involve large intrusions and lava effusions.

Paleogene and lower degree Neogene deposits occur in the northern part of the West Siberia, along the Bering Sea coast and locally in North-East Siberia.

Lower Quarternary deposits distinguished by the remnants of preglacial mountain-coniferous flora and by mammalian fauna, are known in the northeast Siberia. The probable moraine of the first glaciation (Mindel?, Kangan?) is almost completely eroded.

The higher beds are represented by intraglacial sediments (marine and continental) and deposits of the most extensive glaciation (the Riss, the Dneprovian, the Illinoian) with several stages (the Smarovo and the Taz being probably analogous to the Illinoian and Iowan).

Then follow the sediments of boreal (the Eem) transgression which are developed west of Anabar and on Chukotsky Peninsula. On the surface they are almost everywhere overlain by deposits of the last (the Zyrianka) glaciation correlated with the Wisconsin (all phases included). The North-East Siberian Plains are underlain by Late and Post-glacial lake-alluvial deposits.

* * *

REGIONAL GEOLOGY AND PETROLEUM PROSPECTS

LOWER MACKENZIE BASIN AND ARCTIC COASTAL AREA

By J. C. SPROULE
Consulting Geologist

Most of the papers presented during the symposium laid stress "almost entirely on technical aspects" of the geology, geophysics, climatology and transportation techniques of the Canadian Arctic, Dr. Sproule pointed out in his paper. But "many of the conclusions arrived at, however, are of no use to humanity if they do not lead to an economic evaluation of the Arctic as a human habitation and/or as an area from which the human race can derive benefits in the form of gainful production of natural resources."

Dr. Sproule pointed out that Canada and Russia are the two countries most concerned with Arctic development, and while Russia is well advanced with the development of its Arctic areas, Canada "has not yet seriously considered exploitation and related settlement of the far north, including the Arctic in the foreseeable future." He added that this is understandable since Canada has a large area and a small population and that it is only recently that the "government has come to realize that exploitation of the far north appears capable of bearing fruit in the near future using the means at our disposal."

Dr. Sproule "arbitrarily" defined the Lower Mackenzie sedimentary basin as an area bound on the east by the Pre-Cambrian Shield, the west by the Cordillerian Mountain range, and north by the Mackenzie Mountain system.

Criteria already established by the oil search in the provinces can be applied to evaluate the potentialities of this northern area, according to Dr. Sproule.

"The geographical relationship of this area to the areas of vast metallic mineral resources of the shield and igneous areas of the Cordillera is of the utmost importance to an understanding of the future potential of oil resources, metallic mineral resources, and of the entire north country. That geographical relationship in our opinion holds the key to the future of the Northwest Territories and possibly to Canada as a whole."

Dr. Sproule outlined the accessibility of the ar
air, railway, highway and river transportation, whi
"adequate to support the present culture and the p
industry."

The two limitations to population of the area, a
ing to Dr. Sproule, are climate and terrain. While
real problems, these limitations "are not as serio
they are commonly believed to be . . . It is true tha
Arctic gets only three or four months of fine we
in the summer, but how much more do we get here?
predicted that agriculture will be able to support a
population in the Northwest Territories.

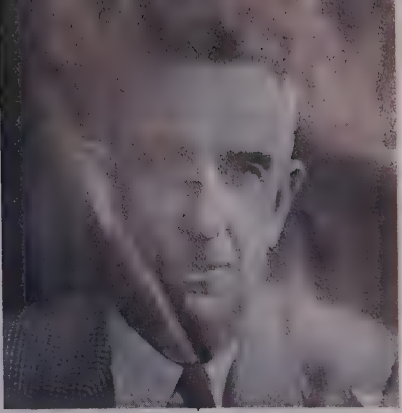
"The geological setting is in many ways abo
ideal as one could wish," Dr. Sproule declared, and
dicted that the sedimentary basin "will unquestio
produce great reserves of oil and gas with relatively
expenditure of effort."

Large areas of the Mackenzie basin "are rela
well exposed and the stratigraphy and structure ca
much better known with less effort. Another res
that oil and gas seeps are abundant and are of su
nature as to speak well for the oil and gas possibili

Dr. Sproule reviewed briefly the principal forma
having oil potential, including a local sandstone i
bottom of the Cretaceous; the Jurassic, not too wel
veloped in the east portion, but containing possib
in the western portion of the basin; the Permo-Pen
vanian, which yielded the Western Minerals Chanc
and gas discovery last year; the Mississippian; the
perial sandstone; the Fork Creek which probably
local reefoid development; the Ramparts, the upper
of which is also reefoid; the Devonian sequences;
Bear Rock, also reefoid; the Ordovician and Sil
which contain both source and reservoir rocks; the
brian, with limited source and reservoir rocks.

onality Profile

ME SERIOUS THINKING, ENTY OF LAUGHTER-- AT'S LIFE FOR LINK



DR. T. A. LINK

hout an enquiring interest in the fundamental the universe, a person misses half the enjoyment And without a sense of humour, he misses the alf.

se are the views of Dr. Theodore A. Link, general n of the recently completed First International ium on Arctic Geology, past president of the cal Association of Canada, the American Association Petroleum Geologists, the Alberta Society of um Geologists, and one of Canada's best known ts.

se two views explain the essence of a man whose combines a powerfully rich blend of scientific y, an intense zest for life, and a keen sense of .

ke your work seriously, but don't take yourself too y," an Eisenhower phrase he likes to quote, also explain the essence of Ted Link.

k's interests are absorbed by almost everything he n contact with—football, astronomy, photography, rling, hunting. In scientific matters, his interests the whole field, at least as much of it as I can and." He skims through an endless stream of ic journals, delves deeply into as many as time .

Sciences Related

l sciences are related," he claims. "If we have a on the origin of oil, it has to fit in with a theory origin of the earth, as well as the origin of life, en the origin of the universe. As a result, the s of physicists must jibe with the theories of sts, and the theories of the chemists must fit the s of the astronomers."

n in Laporte, Indiana in 1897, Ted Link was the a family of 10 (six boys and four girls), the son mall-town minister.

t to a preparatory school which combined an stical training with military training, young Link l his Greek, "decided that this wasn't for me" (both her and grandfather had been ministers) and completed his early education at his home-town high school.

t of high school, his mother had become "a penniidow" and with a family of 10, there were no funds to support further education. But mother ld her brood, "if you don't go to university, you'll as garbage collectors—and we believed her."

Off For Chicago

k headed for the University of Chicago to become ronomer. To obtain tuition he worked as a photor for the school of education, with some additional graphy to earn extra money. For his meals, he l as a cashier at the university cafeteria. To obtain oard in the Museum of Natural History, he served ireguard. "And with the time that was left over, ied."

But life could never be so full for Ted Link that there would be no time left to enjoy it. A chief diversion was the follies. "We'd hawk everything we could to buy tickets at $2.50 a shot." Link will still reminisce at great length and admiration over such follies stars as Al Jolson, W. C. Fields and Eddie Cantor.

After a year and a half of astronomy at the university, Link ran up against calculus. "The prof. told me 'you're just getting started in mathematics'. I decided to quit before I got started and switched to geology."

Follow Interests

His advice today: "Take up that which you like the best and which comes easiest to you. You'll have plenty of competition, but if you've picked what you can best do, you'll be better than average."

His interest in astronomy, however, has never died. A member of the Royal Astronomers' Society, he maintains a large telescope which he built himself and with which he takes colored photographs of the stellar system.

"Studying things outside the earth puts you down to size," he philosophizes. "It gives you a better realization of the smallness of your own importance, and an awareness that humans are not the centre of everything."

Worked For GSC

Graduating with a B.Sc. in geology in 1918, Link worked in Quebec for a short period as a student assistant with the Geological Survey of Canada, then headed for Texas and Oklahoma, working for Empire Gas Co. (now Cities Service Petroleum). Working in Texas, Link answered an ad by International Petroleum, a subsidiary of Imperial Oil, offering geologists work in Peru. The Peru positions were filled but Imperial offered him a job in the Mackenzie area of the Northwest Territories.

"I replied that I wouldn't consider anything less than the then phenomenal wage of $250 a month, plus all expenses."

His decision marked a major turning point in his life. It led to the discovery of the Norman Wells field in the NWT (the 40th anniversary of which is in August) and a 29-year career with Imperial leading to chief geologist in 1944.

Link headed north to carry out geological field work during 1919-21, picked the site for the Norman Wells discovery the first year, brought the well in the second year.

On the first trip into the area in 1919 Link travelled the 1,600-mile route from Edmonton via the Athabasca River to Great Slave Lake and up by the Mackenzie River by steamer. The next year the crew moved a scowload of drilling equipment up the Peace River to Great Slave and the Norman Wells drillsite.

"We were the first and last all-white crew to run the Smith rapids on the Slave River," Link claims. (They had one Indian who Link claims didn't know the country).

"We should have all been drowned. The rapids tore a five-foot hole in the scow and it sank just before we reached land. Shooting through the rapids the scow tilted so much that more than half the bottom was out of the water. We were called a hay-wire outfit, but made record time in getting up there."

First Arctic Flight

In 1921 Link flew in the first plane to enter the Canadian Arctic. The plane cracked up at Norman Wells, and Link emerged with a battered, nondescript briefcase containing $35,000 of company money to buy leases from the Indians. The Indians weren't familiar with large denominations, and bulk of the money was in one dollar bills. "That briefcase really bulged," Link recalls.

When the Norman Wells discovery was brought in, Link predicted it would be "10 years before any of the oil could be used." But within a few years, Imperial had a small refinery at Norman Wells to supply local gasoline demand, principally aviation gas.

Forecasts NWT Growth

During the war he received a call from the U.S. army engineers to boost Normal Wells production to at least 1,000 b/d to support the Canol pipeline project which supplied a refinery moved up from Texas to Whitehorse. During the three-year period 1942-1944 Link directed the geological part of the expansion of the Norman Wells field, increased the number of producing wells from four to 80, the production capacity to nearly 4,000 b/d, and headed a team of 13 geologists looking for more oil fields. They didn't find any before the project was called off, but Link is confident that the day is not too far away when more oil fields will be found in the Northwest Territories.

After working for Imperial for 29 years, Link established a consulting business in Calgary in 1948 the firm of Link and Nauss with partner A. W. Nauss. This later became the firm of Link, Downing and Cook, and in 1956 the consulting business was converted into Cree Oil of Canada Limited, an independent exploration and production company. Cree was acquired by North Star Oil early in 1958 and operated as a subsidiary. Just recently, controlling interest in North Star was purchased by Shell Oil of Canada, and the long-time Imperial geologist sums up these moves by stating: "And here I am working for Shell, of all people."

Big Help For Shell?

At the recent symposium banquet Link, with tongue in cheek, referred to the Shell acquisition of Cree and its seven million-acre land spread in the Arctic Islands by predicting that "this may well be just the thing to put Shell on its feet."

An active sportsman, Link says he has participated "in all sports except hockey, which I think should be played like basketball with an open net." In his sports activities he has included football, curling, golf, hunting, fishing and canoeing—which he doesn't class as a hobby since it formed a part of his work as a northern geologist. Combining his scientific and athletic skills he invented and patented a table-top football game using dice and featuring both forward and lateral movement.

"It doesn't make any money," he claims, "because it was too good. It requires a good knowledge of football in order to play well."

As a director of the Calgary football club in 1928 and 1929 he helped introduce the forward pass into Canadian football, but now finds that football holds less interest because it is "too commercial."

Loud and Long

Link loves a controversial discussion about any but particularly geology and astronomy. "When together with my best geologist friends we argu and loud and love every minute of it."

As Imperial's chief geologist, Link took up res in Toronto in 1944, made his home there until last flying back and forth between Calgary and Toront a month.

Tired of the long, frequent flights between C and Toronto, last year he decided to move west chased a nine-acre home at Victoria with a pan view of the Juan de Fuca strait, and now com regularly between Calgary and Victoria.

Unlike most expatriates in Victoria, he has no to buy a boat, but hopes to enjoy the hospitality BC friends who do own boats. He considers a boat too expensive and wants no part of a small due to a "healthy respect" for the sometimes Pacific waters, which he developed while workin Imperial around the Gulf Islands between Vancouv Victoria.

"I owned a canoe in Toronto and used it reg but sold it when we moved to Victoria. I knew I had it in Victoria, that sooner or later I'd be fool enough to try it on the ocean."

One evening last year the former Indianian ask wife if she noticed anything different about him.

"Like what?" she wanted to know.

"I'm supposed to be a different man now. citizen of a different country."

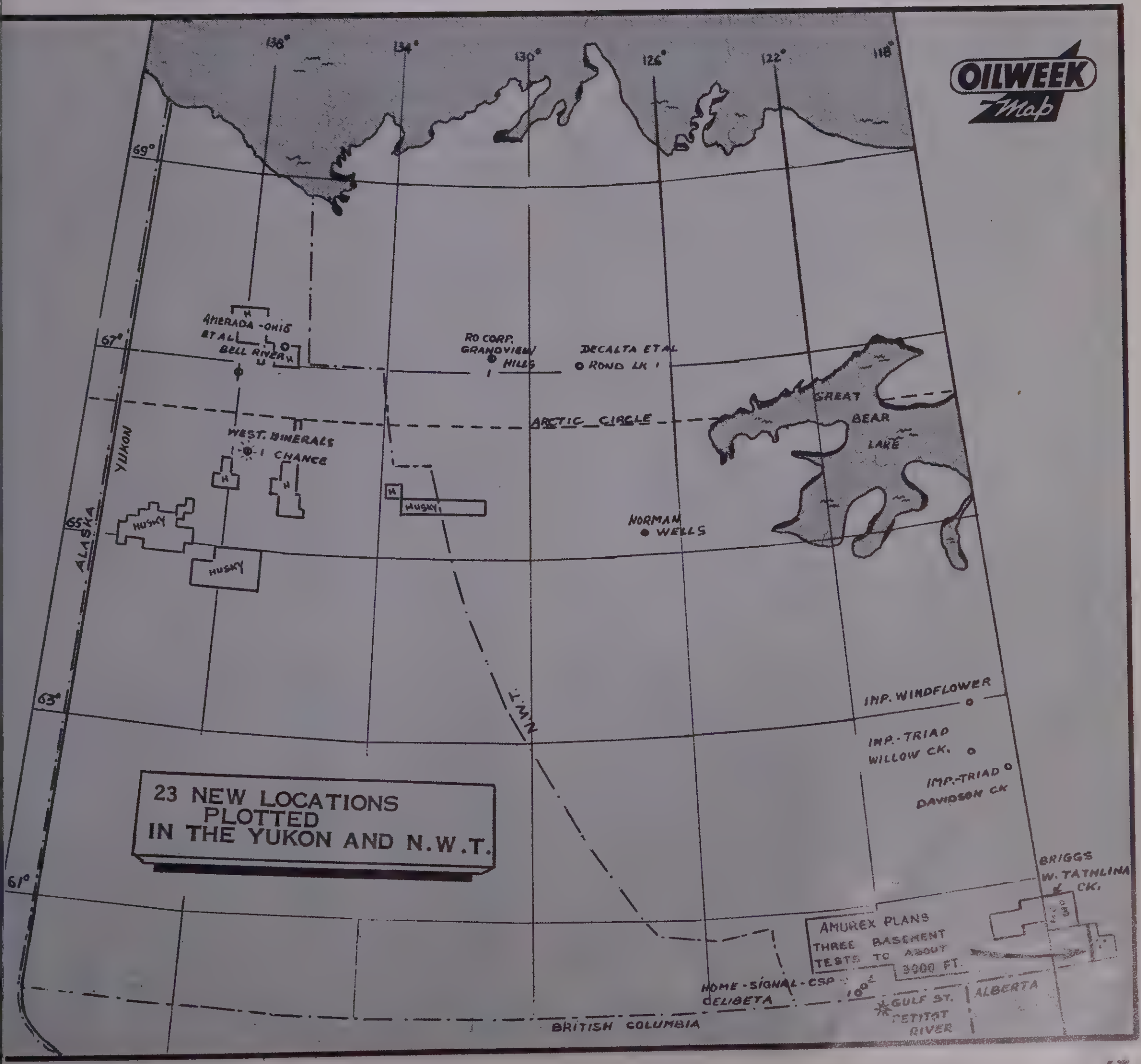
After 40 years in Canada, Ted Link had take final step—he had formally acquired Canadian c ship. But the man who has lived in Canada more two-thirds of his years, who has studied its geology the Pacific to the Quebec Lowlands and from the border to the Arctic, who has done more for C than most Canadians, has long been a Canadian at

NORMAN WELLS No. 1—With a splatter that apparently made the ancient cable tool dri rig shudder in every nut and bolt, Norman No. 1 ushered in a new era for the north with discovery of the Norman Wells oil field.

DRILLING RIGS MOVE IN FOR NORTHERN ONSLAUGHT

About 12 rigs are slated to drill almost 0 wildcats in the Yukon and Northwest erritories this winter as the oil industry's mphasis continues its steady shift northard. Already nine rigs have been moved nto the area and plans now call for the rilling of 23 tests with more expected before e winter season ends.

At least three tests are scheduled north of the Arctic Circle. Biggest factor behind the flurry of activity is the work commitments on the 105 million acres currently held by oil companies in the territories. These requirements, of course, will increase gradually throughout the life of the permits.



About a dozen rigs are slated to drill close to 30 wildcat tests in the Northwest Territories and the Yukon this winter as far northern exploration hits a record pace.

At present, nine rigs have been moved into the north country and plans have been announced for the drilling of 23 tests. More are expected before the winter season is over. In addition, a dozen seismic crews are active in the Yukon and Northwest Territories.

Inside Arctic

Reaching farther north than ever before, at least three tests will be taken down within the Arctic Circle. To date, only one wildcat has been drilled within the Canadian Arctic.

A big factor behind the increasing activity is the work commitments on the 105 million acres now held by oil companies in the Northwest Territories and Yukon Territories. The acreage commitments increase gradually with the life of the permits, and a fair amount of the acreage is now at the stage where the operators must drill or surrender the acreage back to the government.

Work commitments last year amounted to only a few million dollars. This year—although exact figures have not been released—the commitments probably aggregate about $10 million. Next year they are likely to amount to about $20 million or more.

The work commitments — which are applied against acreage deposits — amount to five percent per acre for the first 18 months of a permit; 25 percent per acre for the next 18 months, and thereafter start at a rate of 30 cents per acre per year increasing 10 cents per year to a maximum rate of 50 cents per acre per year.

A rough estimate of the exploration expenditures faced by the industry in this north country is obtained by applying these factors against the amount of acreage held. At the end of 1957 the figure stood at 38 million acres, increasing to 76 million acres at the end of 1958 and 105 million acres at the end of 1959.

No Exact Estimates

Exact forecasts of expenditures on this basis are not possible, because some of the acreage will be dropped without the work commitments being spent, while on other permits the actual expenditures may surpass commitments by a considerable margin.

Nevertheless, these work commitments are a driving force behind the pace of exploration work, indicating a total expenditure in the neighborhood of $100 million over a five-year period.

Here is a run-down on present and planned drilling activity in the Northwest and Yukon Territories, including a rash of new programs announced during the past week:

Richfield Oil Corporation and associates are now drilling the most northerly well in Canada, Richfield et al Grandview Hills No. 1, 67° 06' North, 130° 52.5' West, 45 miles north of the Arctic Circle and 175 miles from the Arctic Ocean. The well was spudded Dec. 26 by Peter Bawden Drilling and is slated as a basement test. Richfield, the French Petroleum Company of Canada, Clark Oil & Refining Corporation and Hudson's Bay Oil and Gas equally share 85 percent interest in the well and 3.5 million acres while Canadian Devonian Petroleum Limited holds 15 percent. Scurry-Rainbow Oils and associates retain a three percent gross royalty on the well and acreage.

Big Moving Job

It took five months to move in the rig and supplies, starting last August and September when the equipment
and supplies were trucked 550 miles from Edmon
Hay River on the shores of Great Slave Lake and
barged another 780 miles across Great Slave Lak
up the Mackenzie River to the landing site, 85
northwest of Fort Good Hope. The final leg of the
was accomplished in late November when su
weather enabled tractors to move the rig 20 miles
to the location.

Amerada Oil Corporation and Ohio Oil have
tively picked the location for the first of five deep
in an $8 million exploration program on a 3.5 m
acre farmout in the Yukon and Northwest obtaine
in 1958 from Canadian Husky Oil and Canadian Su
of California. It will be the fourth test within the
Circle, located about 50 miles west of Fort McPh
85 miles north of the Western Minerals Chance dis
of last summer, 110 miles south of the Arctic Ocea
about 150 miles west of the Richfield driller. Te
location is 67° 19' North and 136° 53' West.

Drilling rig and equipment is now being move
the wellsite, one of the biggest transportation move
undertaken by an oil company in the Canadian
Cost of the move will be so expensive that it is th
that Amerada and Ohio will likely keep the rig
area on a year-round basis until the five-well drillin
gram has been completed. Contractor is Parker D

Shallow Ventures

Imperial Oil and Triad Oil will drill the g
number of northern wells this winter in a shallw-d
area northwest of Great Slave Lake and near the e
edge of the Pre-Cambrian basin. These two com
are slated to drill a dozen wells here this winter.
have announced locations for the first three tests
have moved in two rigs for a continuous drilling pr
Imperial and Triad jointly own about three million
in this area, while Imperial owns an additional
of another three million acres. Some of the test
be joint Imperial-Triad wells, while others will be w
owned Imperial ventures. All 12 wells are slated
taken to the Pre-Cambrian with projected depths of
to 3,000 feet. The three locations announced so fa
Imperial Triad Willow Lake B-20-8 (62° 17' 5"
119° 4' 25" west); Imperial Triad Davidson Cree
(62° 11' 41" north, 118° 15' 11" west), and Im
Windflower G-77 (62° 56' 26" north, 118° 59' 2"

D. Todd Briggs, independent American operato
picked locations for the first two of a multi-well s
drilling program southwest of Great Slave Lake and
35 miles north of the Alberta border. Two rigs are
used. The two wells now drilling are: Briggs West
line Lake No. 2 (60° 38' 17" north, 117° 47' 27"
and West Tathline Lake No. 3 (60° 40' north, 11
27" west).

Three For Amurex

Amurex Oil Company plans to drill three we
basement tests to about 3,300 feet this winter on a
of seven permits covering more than 400,000 acres
Hay River area. The land adjoins the Alberta
and is centred about 50 miles southwest of Great
Lake.

Western Decalta Petroleum and associates are d
the first test in a multi-well shallow drilling pr
within the Arctic circle, Decalta et al Rond Lake
(67° 04' 30" north, 128° 28' west). Site is 65 miles
southeast of the Richfield Grandview driller an
miles east-northeast of the Western Minerals C
No. 1 discovery. The well is slated as a Devonia
to 1,500 feet and is located a mile down-dip fro
largest natural oil seepage so far found north of N
Wells. The seep, claimed to be quite extensive in

g 18 to 20 gravity oil. Participants with Western (30 percent interest) include Supertest Petroleum Canpet Exploration (each 30 percent) and New ntal Oil Company of Canada (10 percent). Glacier rs retains a 25 percent net carried interest.

Deepening Discovery

stern Minerals and associates are deepening their n Minerals Chance No. 1 discovery (66° 7' 42" 137° 31' 42" west) which last summer flowed gas s up to 10 mmcf/d together with light gravity an unspecified rate on a 120-foot interval below feet in the Permo-Penn. Projected total depth is 8,000 feet. The discovery lies 50 miles south- st of the group's Eagle Plains abandonment, drilled ears ago, which was the first wildcat in the Cana- rctic.

Home

me Oil Company and associates are drilling the o wells on a 1,224,000-acre farmout from Canada rn Petroleum in the Celibeta Lake or North Peti- a, adjacent to the British Columbia border. Home Celibeta No. 2 (60° 07' 22" north, 122° 15' 42" will go down 30 miles northwest of the big BC scovery, Gulf States Petitot River, while Home Celibeta No. 1 (60° 3' 37" north, 122° 22' 44" s being drilled five miles southwest of the No. 2 5 miles northwest of the Gulf States discovery. wells are slated as Devonian tests to about 4,500 n order to earn a half interest in the farmout block ome group is paying Canada Southern and asso- $3 5 million cash and in addition will carry out million exploration program over a five-year period. will earn a net 12.5 percent, Signal Oil of Cali- will earn 25 percent, Kern County and Alminex ch earn five percent, and United Oils will earn 2.5 t. Canada Southern retains 37.5 percent while lan and Oil Investments Inc., each retain 6.25 per-

★ ★ ★

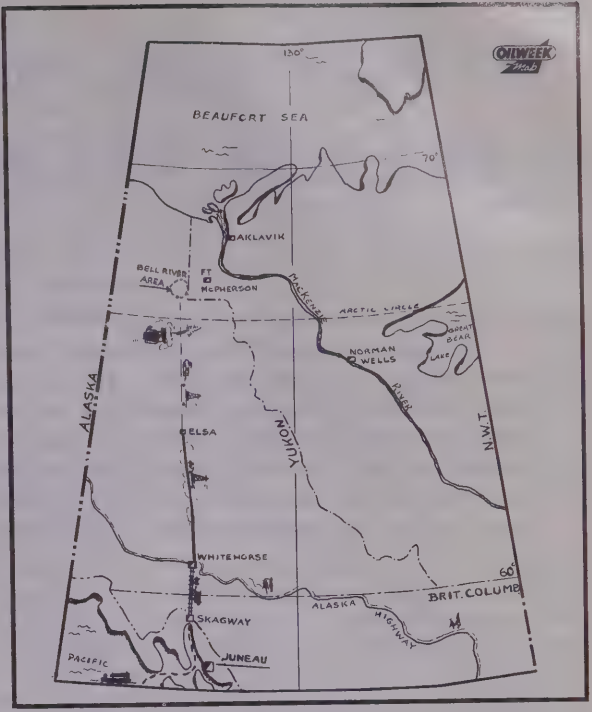
ving Rigs Into Far North nstitutes Major Problem

ovements of drilling rigs, equipment and supplies ldcat ventures in Northwest Territories and Yukon ories involve major operations. The transportation ally the biggest single item in the total cost of a g program, and frequently it costs as much as a worth to move it to the drillsite.

e most customary transportation methods used to isolated far-northern operations include river barge, trains and special muskeg and snow vehicles. ies are usually brought in by plane.

nerada and Ohio, moving in a big rig for their t west of Fort McPherson, are using standard high- rucks over a specially constructed 380-mile winter o the wellsite. This marks the first time that oil quipment has been trucked above the Arctic Circle standard highway equipment, and the winter trail farthest north route in North America connecting an established highway system.

ontractor Parker Drilling Company's rig is being d from Edmonton via the Alaska highway and the r trail to the wellsite, while other supplies and ment are moved by boat from Vancouver to Skag- from Skagway to Whitehorse by the White Pass & n Railway and from there to the wellsite by White rucks.



g diesel trucks with semi-trailers are hauling freight north to the site of the Amerada-Ohio oil hunt by means of the 380-mile winter trail from Elsa on the Mayo-Elsa highway, over the Braine Pass, up the Wind River, over the Peel and Hart Rivers and through the rolling hill country to the Bell River area.

Amerada-Ohio freight is transported over regular White Pass facilities from Vancouver, BC, to Elsa, Yukon where the new Wind River winter trail staging camp is located.

Freight is forwarded from here by standard highway diesel trucks over the frozen mountainous winter trail to the Bell River area of operations.

The trail was built by Arctic Oil Field Transport Ltd., a company jointly sponsored by the White Pass & Yukon Route and Proctor Construction Company Limited. The White Pass & Yukon Route is the principal shareholder of this concern.

Construction commenced October 12, 1959, and was completed January 11. The work progressed at about four miles per day. This included building bridges of logs which were obtained on site. Road gravel was found over most of the route with only a little seasonal frost in it. No permafrost was encountered.

A regular maintenance program has been devised to keep the trail in good repair and free of snow while it is in use.

The first loads of Amerada-Ohio arrived at the Bell River area immediately behind the road trail building bulldozers.

"It is our contention that northern development and transportation facilities are synonymous," said C. F. Abrams, president of the White Pass & Yukon Route. "This latest White Pass undertaking is part of a continuous pattern of investment in northern development which was first established when we constructed the railroad in 1898-99," he added.

The White Pass & Yukon Route was built before the turn of the century to serve Yukon during the Klondike gold rush.

FROM OILWEEK, MARCH 5/60

GETTING OIL TO MARKET MAJOR PROBLEM IN NORTH

By JOHN CRESSEY,
Assistant General Manager,
Banister Construction Ltd.

A short time ago, the most northerly well ever drilled was spudded in. This gives rise to some interesting conjectures as to what will happen in the event a substantial amount of oil or gas is located. During the past few months petroleum reservations have been taken on approximately 80 million acres in the continental Canadian north, and geologists seem to have little doubt that large petroleum reserves will be located in these areas. It is evident that the search for petroleum products is now moving into what is perhaps the most inaccessible area of Canada and it poses many problems.

The development of petroleum reserves in any given area can easily be divided into the distinct and separable phases of reconnaissance, exploration, development and transportation. The first three phases would be concentrated in the area where the wells are located and the transportation of the product would commence at the wellhead and continue through totally undeveloped terrain to the point of delivery. In this article we are interested only in the transportation of the product.

The problems faced by each phase up to the point where the product is ready for delivery to market are unique to that particular phase. The successful solution of supply problems of the exploration and development crews only have limited application to mobile pipeline construction crews. They do serve to develop a means of gaining access to the wellsites but this is where our operations commence and consequently from this point on we are on our own.

The centre of attention as far as mid-northern drilling is concerned is the Grandview Hills lease of Richfield Oil et al, which is approximately 45 miles north of the Arctic Circle and 174 airline miles from the Arctic Ocean at Mackenzie Bay. This is a remote area and in order to discuss problems of pipelining in these areas we will assume that a substantial oil strike is made here and it is decided to build a pipeline to Whitehorse and thence to Haines where tanker access is available and a tie in is possible to the American military market via the existing products pipeline to Fairbanks.

In order to circumvent discussion of markets and secondary transportational facilities we will discuss the line from the point where it commences in the Grandview Hills to an undetermined point where road access is available from the existing Yukon road network to the west.

Idea Not New

The building of a pipeline in the Canadian north is not a new and unprecedented venture. Two lines have been built there since 1947. Because of technological innovations we can now lay pipe in these remote areas considerably cheaper than 15 years ago. The first line to be built in the north was the CANOL project which was built during the latter part of the war to transport oil from Norman Wells to Whitehorse and on into Alaska. This line was abandoned and partially taken up shortly after the war. The second and most recent line was a products pipeline built from Haines to Fairbanks, A
which traversed approximately 350 miles of the
Territory. These projects both had one thing in co
they were built through military necessity.

One of the first decisions to be made by the o
company before calling tenders would have to be w
to coat and bury the line or leave it bare and o
surface.

The two previous lines built in the territories
both bare and unburied. The problems of constr
would be greatly simplified if the line were left un
except for river crossings and sharp ravines. If th
is left unburied except in the aforementioned critical
it would be useless to coat the pipe as the expansio
contraction of the line across and along the RO
provide sufficient abrasion to quickly wear conve
coating off the pipe. There are several sound r
for ditching and burying a pipeline, but perha
major one is that it puts the pipe undergroun
enough to remove it from harm.

In the case of farm and lumber operations it faci
complete and undisturbed use of the ROW for all
tions subsequent to the line being built. By b
the line in a ditch you confine the area through
it can work, through expansion and contraction
is therefore possible to ensure that no rock or
abrasive material is under or over the pipe and
easy to preserve the protective coating and pipe
harm.

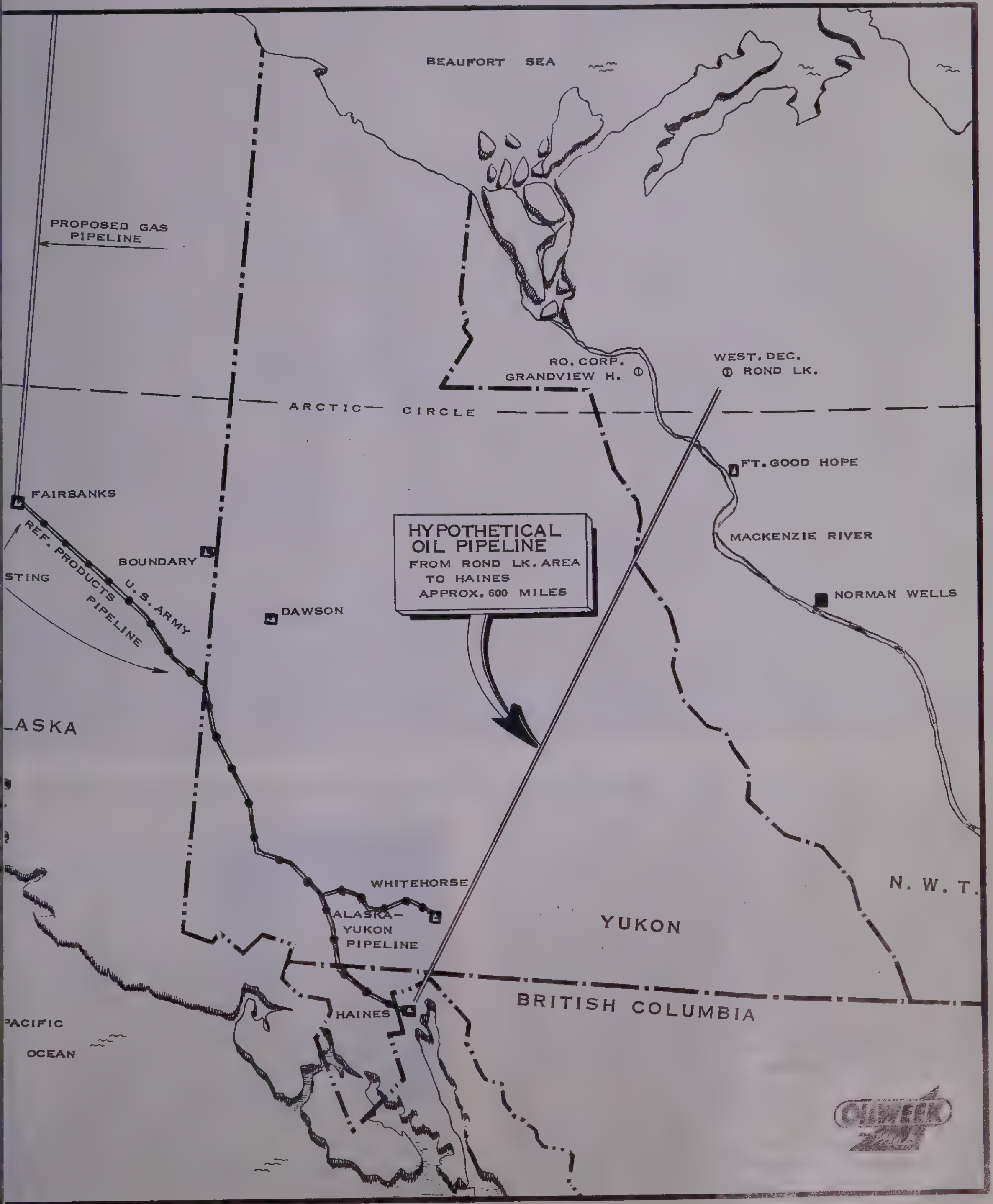
In the Canadian north we have several valid r
why the line should not be buried, the foremost of
is cost. The line would cross large areas of perm
where the ground remains frozen all year round. In
to ditch this type of soil it is necessary to blast, a
ventional back-hoes and trenching machines are
to economically ditch for extended periods under
conditions. If the ROW is properly cleared of s
and rock and properly graded, the surface wou
relatively smooth and the amount of abrasive d
to the pipe from working on the ROW would be
mized. It must be remembered that the tempe
range in this area can be as much as 180° F. an
expansion and contraction of a line during the cou
a year would be considerable. Careful location of a
or tie-down blocks would restrict this movement in
areas.

re is relatively little danger of damage to the line achinery traversing the ROW as the territory is and for the most part unoccupied. For the first rs, the existing ROW would be clearly discernible the absence of trees and shrubs in the wooded d the tracks, etc., in other areas. Notification of ence would not be difficult and this matter need further discussed.

uming that the line would not be buried, phase the construction could commence in the winter. amps would be established at either end of the line and clearing crews set in to head toward each other over the surveyed ROW. As these crews moved together maximum utilization of machinery must be made in order to keep the manpower of the crews to a maximum.

Transportation Troubles

Line pipe for this area could be shipped to the western end at any time of the year; however pipe for the eastern section of the line would have to be trucked in the summer to Hay River on the south shore of Great Slave Lake and then barged down the Mackenzie River approximately 750 miles to the field location where the line



starts. The pipe could then be stockpiled at this point while awaiting the advent of winter so that tractor trains could haul and string the pipe on the ROW behind the clearing crews. By moving the pipe with dozers and booms it would allow the use of these tractors for the actual laying operation and reduce the duplication of equipment on the job.

The clearing crew would have to preserve all materials suitable for rip rap in the proper length for immediate usage. They could then rip rap the muskegs as they came to them, enabling the foreseeable bad spots to be prepared ahead of time.

In the event it were decided to coat and bury the line, all dope, primer and paper should be hauled into the project and spotted at mile intervals along the line. This would reduce the amount of necessary ROW traffic during the wet season and keep the ROW and rip rap relatively intact.

It would be advisable to commence welding as early as possible in order that a maximum amount of ground could be covered prior to the frost coming out of the muskegs. Bending could be done during the winter.

Special Needs

With the advent of spring it could well be necessary to abandon conventional means of transporting the men to and from the camp-sites and resort to special muskeg equipment. This equipment is not, however, suited to ROW use where the ROW has been torn up by heavy tracked equipment as the mud and rip rap are extremely hard on equipment designed primarily for muskegs. By-pass routes would have to be made as this type of equipment functions better on muskeg than it does on the rip rap and heavy mud that we can expect to encounter on the ROW. The major problem of off-ROW travel is that the muskegs must remain relatively intact otherwise they, too, become impassible to muskeg tractors. After seven to 15 passes the route must be changed as the fibrous and soil components of the muskegs become compacted under the tracks and you are going through plain water which cannot support this type of vehicle. It would be necessary to space the camps at short distances so as to reduce the miles of man-haul to the job site each day.

This would necessitate the establishing of extra camps which would not be hauled out until the following winter but nevertheless this cost would be small in comparison to the cost of transporting large numbers of men across country through muskeg areas to and from distant camps each day.

The speed at which the pipe-laying could progress would be regulated by the condition of the ROW which would dictate what type of vehicle could be used and what progress they can make. Access to, and egress from, the point where work is going on constitutes the biggest single problem in such an operation and if this time element can be reduced to a period not greater than two hours per day each way, the operation can proceed economically and efficiently. As mentioned previously the size of the crew must be minimized through complete and efficient utilization of machinery and manpower wherever possible. Each employee should be at least capable of performing two trades. Capable mechanics would be very handy and there would be no extra cost to this type of employee.

Communications Vital

Communications on a project such as this are of the utmost importance. It would be physically impossible for a foreman to drive 20 miles to the warehouse to pick up a few bolts that one of his operators forgot. A highly organized and efficient autonomy is necessa each phase of the operation as not only distance but difficult terrain would separate one crew from the and travel must be restricted on the ROW. The many places where the only communication wou by word of mouth. Rip rap is notorious for jarring equipment, mounted on tractors, out of order in a time. It would be impossible to use any form of r tired motor vehicle during the summer and proper s vision would therefore only be accomplished by scout car or other tracked muskeg vehicle. At no could heavy tractors be used for transporting wo up and down the ROW as this would only serve t it up. Safety and first aid facilities must be u on an individual crew basis rather than one such tea the spread. Because of the relatively isolated pos of each crew while out on the line they must ea capable of looking after their own needs in this rega

In the event that ditching was necessary the ditch equipment would have to move on to the job the frost has left the ground in the non-permafrost Large capacity ditchers would be extremely useful in areas provided the terrain dried sufficiently, but ventional trenching equipment would be useless in p frost and muskeg areas. In these areas we must the permafrost and then hoe out the residue and ments and quickly coat and place the pipe in the before the permafrost ditch weeps too much and c the ditch to sluff and fall in. In the muskeg it be possible to ditch with conventional back-hoes equ with wide pads and mats.

Supply Problems

The supplying of camps would be a major pro but by keeping the personnel to an absolute min and stockpiling as many of the foodstuffs as possib the winter it is feasible that once a week supply could be used. Luxuries at camps such as these have to be few and far between due to the pro of access. This should not prove to be a major pro however, as the crews would not be isolated for too a period of time.

It would appear that the major problems to be by the pipeline contractor are similar to those by the exploration and drilling crews; however our lem is accentuated because more men and equip are necessary for our operations and, unlike the dr crews, are not located in one spot for relatively long pe of time.

A. J. Cressey is assistant general manager and president of Banister Construction Ltd.

A native of North B ford, he served with Fleet Air Arm of the dian Navy during World II, and graduated from University of Saskatch in 1955 with B.A. and degrees, articling in la Alberta following his gra tion.

While attending unive Mr. Cressey spent his mers working on pi crews in western Ca and joined Fulton Banister as personnel director in In spring of 1959 he was appointed assistant ge manager of Fulton Banister and general superinten and early this year was appointed to his present pos

THE FACE OF THE NORTH

rig moves in north of the Arctic Circle

tle Chicago is an abandoned fur trading post on nks of the Mackenzie River, 180 miles from the Ocean. Established by a latter-day frontiersman, Johnson, the small post was a tiny dot of civiliza- . a vast wilderness.

New Type of Frontiersman

st August, a barge unloaded a tractor, equipment ıel oil at Little Chicago. A new type of frontiers- ad arrived in the north to prepare the staging point hfield et al Grandview Hills No. 1, 45 miles inside ctic Circle and the most northerly well drilled in a.

iginated by Scurry-Rainbow Oils and Associates, the e was later taken over by Richfield Oil Corporation ssociates, including the French Petroleum Company nada, Clark Oil and Refining Corporation, Hudson's Dil and Gas, and Canadian Devonian Petroleums. nearly half a year of planning, carrying out preparatory work and moving some 1,700 tons of equipment more than 1,300 miles by truck, barge and tractor train, contractor Peter Bawden Drilling Limited spudded the well in on Christmas Eve.

At Little Chicago Bawden men used the summer months to clear the staging area, erect storage tanks to hold 1,500 barrels of diesel fuel for the drilling rig, and build a landing jetty for the barges which would later move in the equipment.

Rig 16 Loads Up

At Spirit River in northwestern Alberta, Bawden's rig No. 16, together with camp facilities, drilling mud, casing, tubing and a thousand and one items of supplies were loaded aboard a truck convoy and headed up the Mackenzie highway for Hay River on Great Slave Lake. The 500-mile trip was completed in three days and the big loads transferred to river barges. On Sept. 17 the river tug Charles Radium pulled out of Wrigley Harbor nea

FIRST STEP was to train Eskimos as drillers. Mike Selamio and Frank Joe Esagok get their initial lessons by watching movies. Personnel manager W. D. Blackie operates the projector. (Top left).

A COMPANY PLANE lands the first personnel at Little Chicago, the staging point, mile 778 on the Mackenzie River. Equipment will be assembled here later. (Centre left).

STAGING AREA is cleared and a landing jetty prepared for arrival of equipment by barge. (Top right).

STORAGE TANKS are constructed at staging point to hold rig's fuel supply. Here, tank bottom is being laid. (Centre right).

COMPLETED TANKS will hold 1,500 barrels—500 in the smaller tank and 1,000 barrels in the larger tank. (Lower right).

ver pulling barges loaded with trucks and tractors No. 16, headed for Little Chicago, 1,300 miles ream on the Mackenzie River.

Fuel From Norman Wells

m Imperial Oil's Norman Wells refinery the Charles picked up a fourth barge. The fuel barge held 100,000 gallons of fuel oil, diesel oil and aviation feed the drilling operations throughout the long months.

Sept. 21 the Charles Radium and its string of four barges landed at Little Chicago. For three days arles' crew and Bawden men worked around the n freezing weather and knee-deep mud unloading t amount of supplies.

Build 23-Mile Road

th the early freezing weather, the slippery, sticky mud turned hard, and tractors were able to bull- 23-mile winter highway from the staging point to andview Hills wellsite. Then tractor trains started g tedious job of moving this equipment to the well- he round trip of 46 miles took an average of 25 To keep the tractor trains moving day and night were used to change tractor operator shifts. A che was established along the route to supply the s.

eks later a drilling camp was slowly being led, the big rig was being placed together. Crews vorking round the clock in weather that hit 50 zero and with only four hours a day of rather dim t. A landing strip was prepared on a nearby lake eter Bawden's big DC-3 aircraft made regular led flights into the area with more men, materials, ent, supplies and even some prefabricated build-

Spud on Christmas Eve

Dec. 17 the rig had been assembled and the draw- were hoisted skyward. On Christmas Eve, the well drilling.

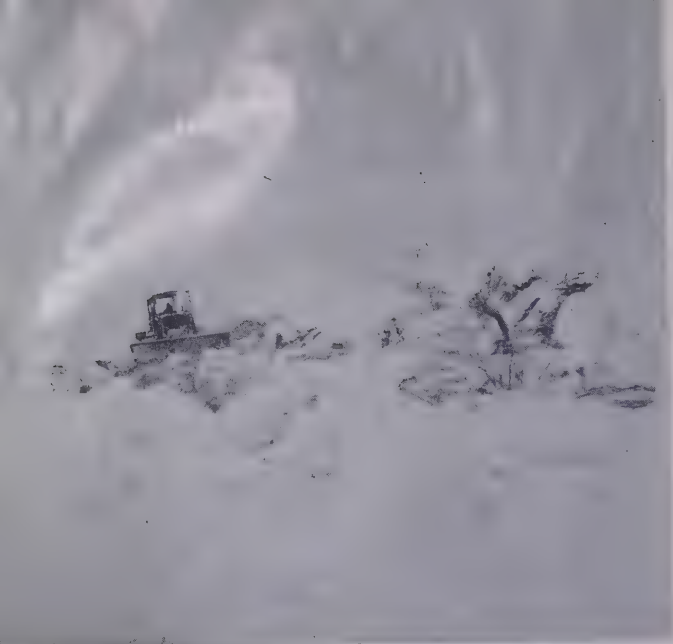
Peter Bawden Drilling and the Richfield team, ghest part of the task was over.

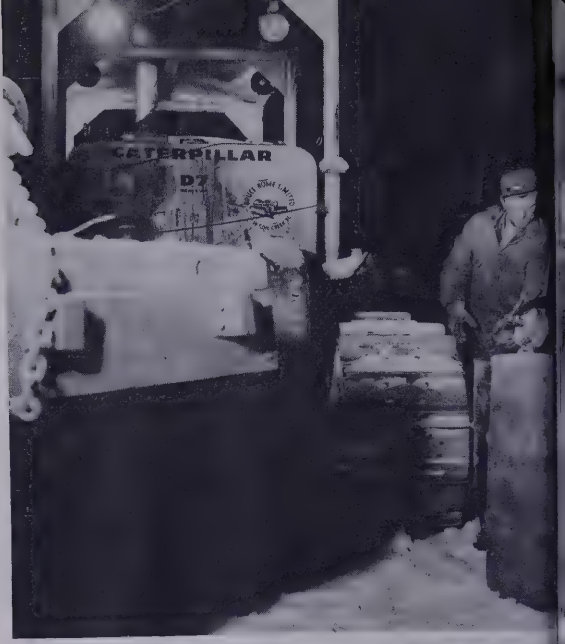
HOTOS FROM PETER BAWDEN DRILLING

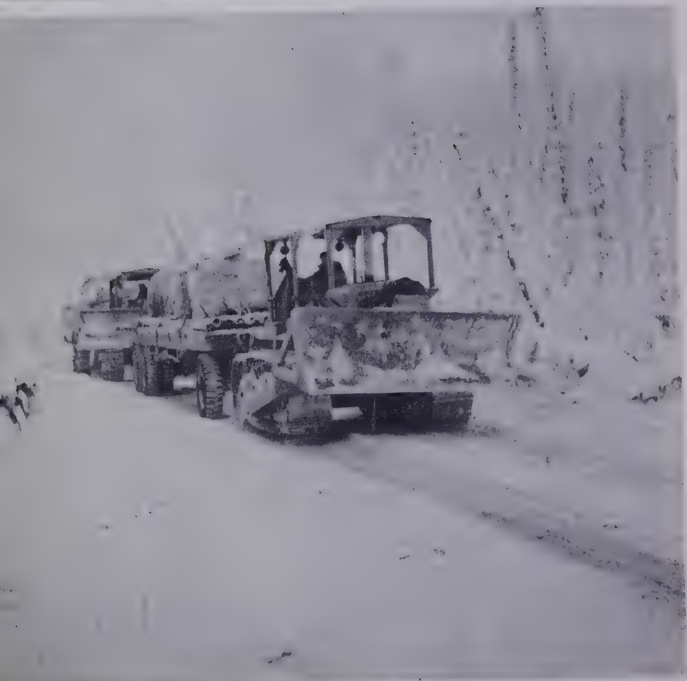
EQUIPMENT-LADEN BARGES arrive at staging point Sept. 21 after 800-mile trip from Hay River. Fuel oil was picked up en route from Imperial Oil's Norman Wells refinery. Four barges carried 1,700 tons. (Lower left).

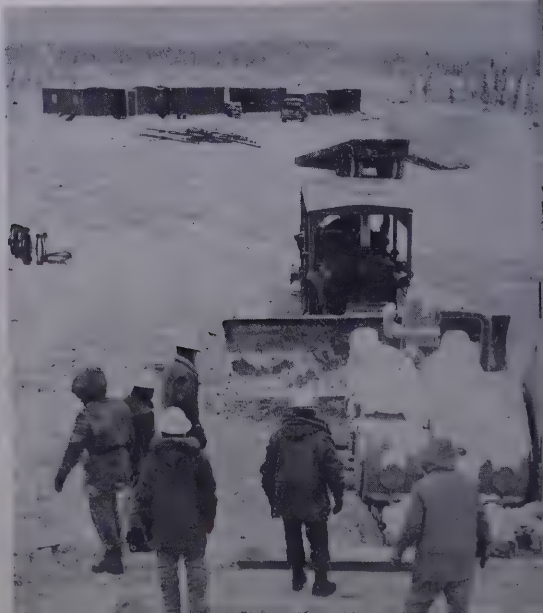
UNLOADING took three days. Here, big-inch strings of surface casing are unloaded, suspended in mid-air from the booms of two tractors. (Centre right).

AIR LIFT also played a big part. Prefabricated buildings are loaded on company's DC-3 aircraft at Airdrie, near Calgary, for long flight to Grandview Hills. (Lower right).









PUSHING NORTH into virgin country these tractors are building the 23-mile winter highway from Little Chicago to the wellsite. (Top left).

TRACTOR TRAINS move in the drilling equipment and camp buildings. The tractors took 25 hours to complete the 46-mile round trip, and planes were used to change shifts of tractor operators. (Centre left).

FUEL CACHES were used to keep the tractors supplied on the trips between Little Chicago and Grandview Hills. (Top right).

IT'S REALLY WINTER by the time equipment and camp facilities are assembled. Communications are established with raising of radio mast. (Centre right).

ASSEMBLING RIG, the mud pumps are here being placed into position. (Lower right).

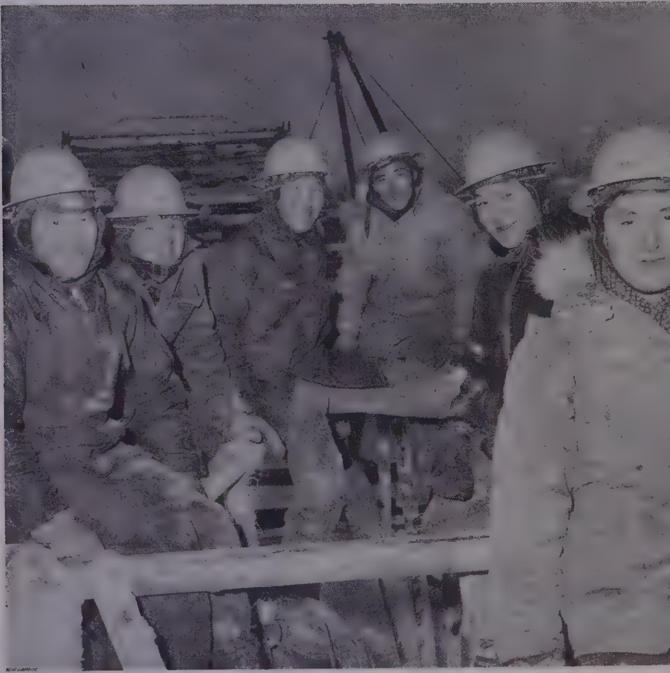
DERRICK SECTIONS are pinned together before raising mast. Crews worked in temperatures of 50 below zero, with only four hours a day of rather dim daylight. (Top left).

ALL PINNED TOGETHER, the 133-foot oilwell mast of Bawden's rig No. 16 is ready for work. (Centre left).

UP SHE GOES! After waiting four days because of the danger of damage in the brittle cold 40 below weather, the temperature rose to about zero and the mast reached skyward on Dec. 17. (Lower left).

NOW SEASONED DRILLERS, these Eskimos, who started training with Peter Bawden Drilling early last year, played vital roles on rig 16. Left to right, Laughingwell Singatok, Elias Anivgana, Joe Panuktuluk, Charlie Thraser, Frank Joe Esagok and Elijah Allen. (Centre right).

CANADA'S MOST NORTHERLY DRILLER, Richfield et al Grandview Hills, spudded in on Christmas Eve.



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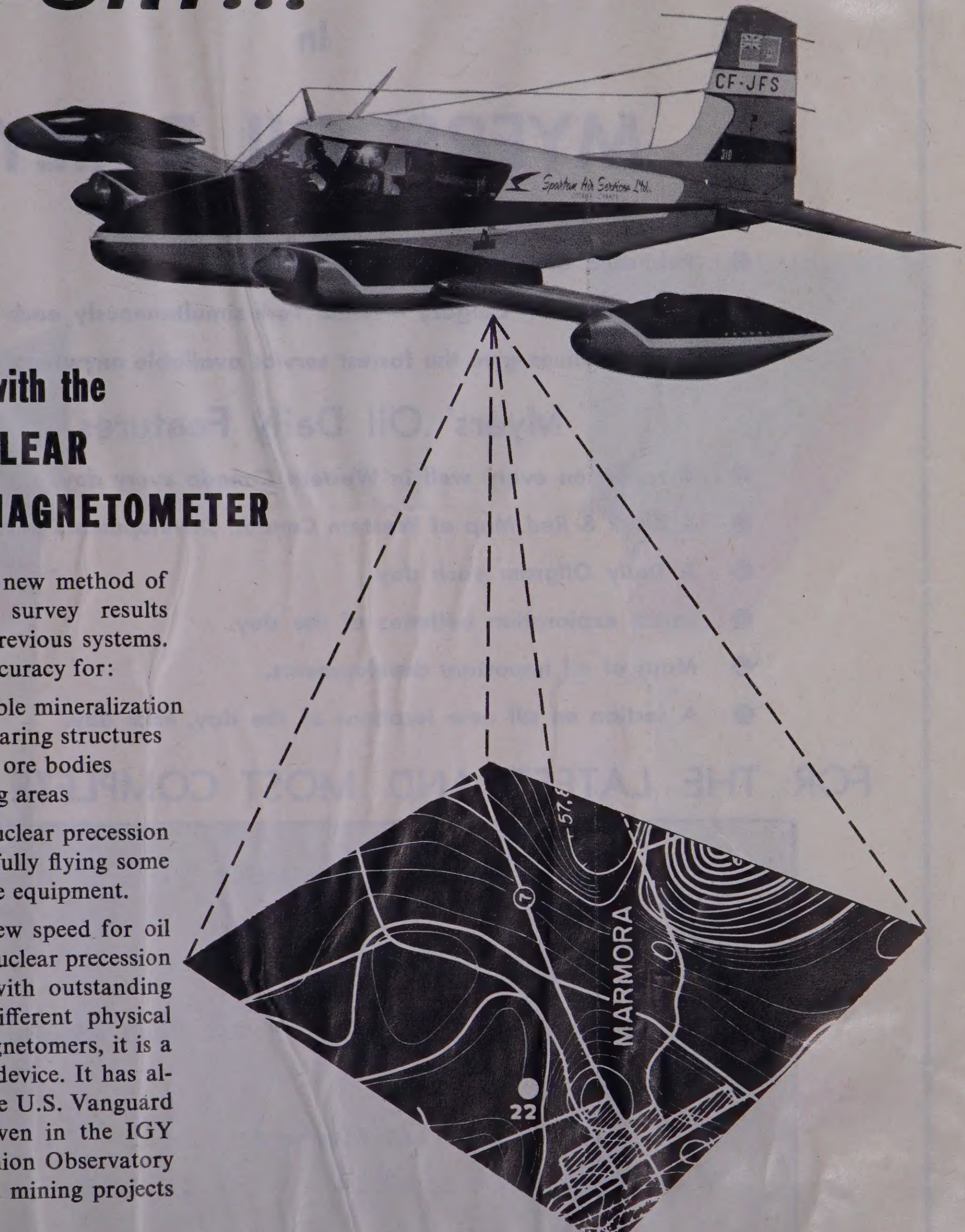

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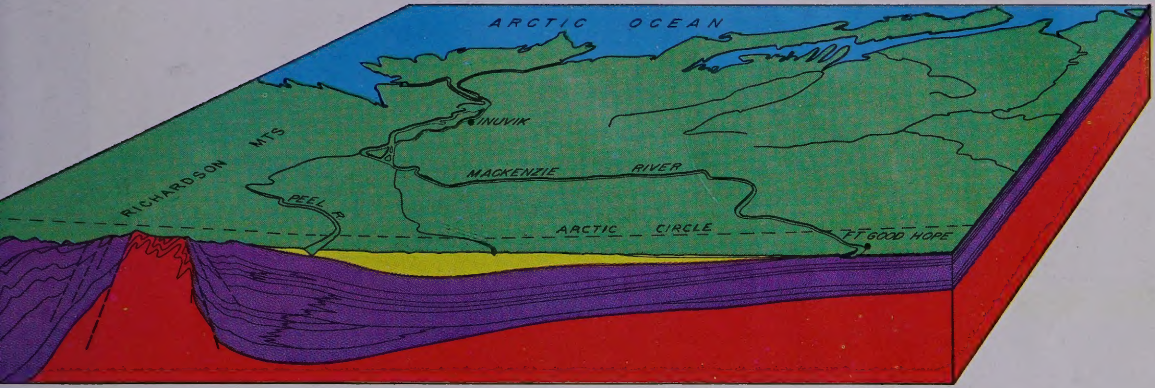

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